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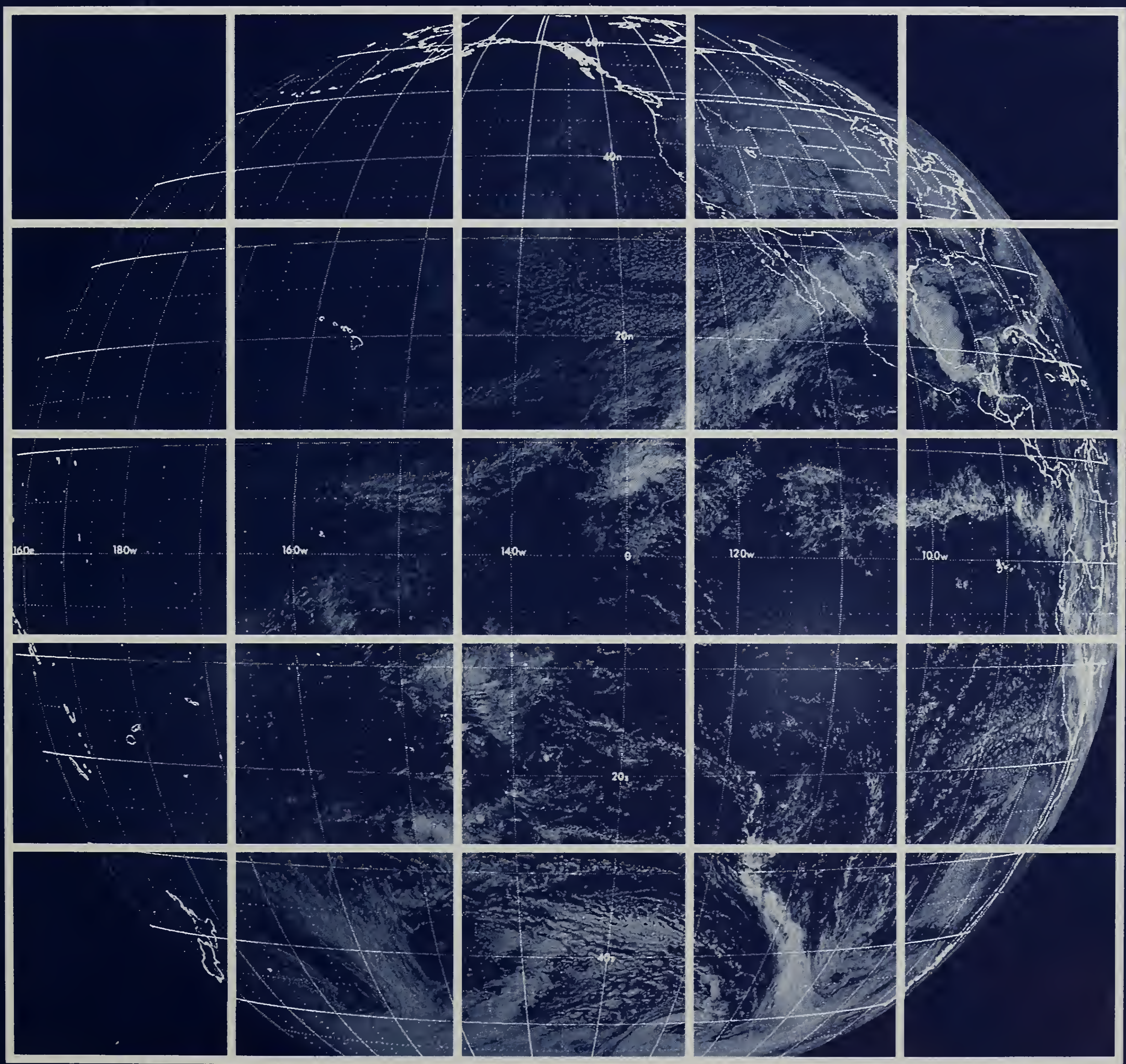
Environmental Policies

Implications for Agricultural Trade

John Sullivan



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Environment & Pollution

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Abstract

This report, consisting of 14 separate articles, analyzes some of the linkages between environmental policies and agricultural trade. Topics covered include: a global inventory of environmental policies, the implications of environmental policies on U.S. and world agricultural trade, the implications for environmental policy in the context of multilateral and regional trade negotiations, and the effects of global climate change on agricultural trade.

Keywords: environmental policies, agricultural trade, inventory and analysis, trade negotiations, global climate change

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Contents

Summary

This report explores data needs and indicators, examines the institutions addressing trade and environment issues, and begins an analysis of the implications for agricultural trade of changes in environmental and agricultural policies. Examples of modeling exercises are presented, in an attempt to bring into focus some of the many possible interactions between trade and environmental policies. This report also includes surveys and case studies of issues related to trade and the environment.

Following the introductory chapter, the first five papers (Chapters 2 through 6) focus on environmental policies and standards and on institutions governing and affecting global environmental issues. Beattie compares economic measures of living standards across countries, including environmental degradation. More specifically, she examines efforts to include price measurements of "environmental depreciation" in the System of National Accounts, in response to charges that traditional measures of economic growth undervalue the natural resource base and overestimate social welfare. Mabbs-Zeno and Antle lay out a theoretical basis for quantifying the environmental impacts of policies designed principally for agricultural purposes. The article by Gray and Vocke, based on the forthcoming Global Review of Resource and Environmental Policies, provides a status report on environmental policies relating to land, water, agricultural chemicals, and wildlife for about 25 countries. Gray and Vocke concentrate on water and land policies.

Mabbs-Zeno describes the programs of multilateral institutions directed toward environmental issues and how international lending policies have changed to reflect environmental concerns. Skully continues the discussion on multilateral institutions, emphasizing the role that international organizations may have in resolving disputes over product and process standards. The international institutions that attempt to mediate, regulate, and standardize environmental and health standards are surveyed as to how they resolve these issues.

The rest of the report consists of papers on environmental policies and their potential effects on trade. These start with the paper by Gray and Krissoff, which lays out basic economic principles for use in analysis of agricultural trade and the environment. The following articles take a regional perspective: three papers examine trade and environment issues relating to Western Hemisphere concerns, two papers focus on the European Community's environmental policies and their effect in EC and world agricultural trade, and one article addresses Malaysia's ability to sustain its exports of tropical lumber.

Anderson's article discusses the impact of NAFTA-induced freer trade on longer-term agricultural environmental issues, particularly for Mexico. The article discusses agricultural environmental concerns and issues in Mexico and the United States, and projected environmental consequences of NAFTA. Ballenger, Beattie, and Krissoff look at potential agricultural trade agreements in the Western Hemisphere. This issue is explored in a conceptual model and in empirical case studies. In the conceptual model, the authors find that regional trade agreements may set the stage for a bargain between groups in the "North" representing environmental interests, and groups in the "South" representing trade expansion interests. The case study considers a preferential trade agreement for a single commodity and the regulation of an environmental externality involving pesticides associated with the production of that good. In the third article related to Western Hemisphere agricultural trade and the environment, Forsythe and Evangelou examine a possible future ban on the use of methyl bromide for treatment of imports.

Leuck analyzes the effects of the passage of a regulation by the EC environmental ministers that limits the application of nitrogen-containing manure and chemical fertilizers in areas where nitrate levels are already high. Some areas of the EC are to be designated "vulnerable zones" where fertilizer and/or manure application must be reduced. Restrictions on livestock density in these regions are expected. Haley's article includes a description of EC environmental problems and their relationship to agriculture, with an emphasis on the role of EC policies in encouraging the intensification of both livestock and crop agriculture. Several new directions in EC agricultural and environmental policies are considered.

Giordano's article focuses on Malaysia, but takes the form of a case study of a sustainable agriculture issue. Malaysia possesses some of the largest tracts of tropical forests in the world, and is the world's largest exporter of both tropical logs and sawn timber. However, growing realization of the environmental degradation caused by deforestation and a recognition that logging rates of past decades have been above those sustainable on a long-term basis have prompted changes in both timber extraction and export policies. Recent policy innovations have caused a decline in timber extraction rates and a radical shift in the composition of exports toward relatively high-valued wood products.

The report concludes with an assessment of the potential effects of climate change on agricultural trade. While the magnitude of the global problem is debatable, many agree that significant regional agricultural problems are possible. The final article by Darwin, Lewandrowski, McDonald, and Tsigas reinforces this point. Looking at shifting uses for natural resources in a changing climate, these authors find that improvements in analytical capacity to assess potential geographic shifts in land classes allow them to pinpoint some potentially disturbing shifts in agricultural production.

Environmental Policies

Implications for Agricultural Trade

Chapter 1
Introduction

John Sullivan[1]

The global community has recently become more concerned about the environment, making it one of the leading issues of the 1990's. Many of these issues, which include water quality, soil erosion, deforestation, product safety, and protection of wildlife and biodiversity, and the policy measures adopted to deal with them, relate closely to agriculture and agricultural trade. For analysts of agricultural trade, the environment may be the most important trade issue of the 1990's.[2]

This perception of environmental importance follows several long-term developments strengthening the threat from environmental degradation. As the global community responds to these problems, it challenges existing international arrangements to absorb an additional mandate, sometimes forcing compromise on such traditional priorities as commercial trade in favor of sustainable production and safe consumption.

International environmental protection began concurrently with domestic programs nearly 150 years ago as colonial administrations recognized the dramatic impact they were having in less developed areas of the world. The British passed legislation to protect open areas near Cape Town in southern Africa in 1846. Also, acts to protect forests and game in southern Africa were passed in 1859 and 1886. In comparison, the first national park in the United States (Yellowstone) was formed in 1872. The seven European countries with African colonies met in London in 1900 to sign a convention for animal protection in Africa. A broader environmental agenda was pursued by industrialized nations in 1909 at the International Congress for the Preservation of Nature. By the mid-1930's several international governmental organizations had been formed for environmental protection.

A new approach to international environmental action emerged during the 1960's from developments in the science of ecology and from the rapid extension of transportation networks that linked countries more closely. These efforts did not result in strong international commitments, however. The Stockholm Conference of 1972 represented broad recognition of environmental issues, but it resulted in little concrete change of policy.

A variety of international agreements have followed to address the use of natural resources that are shared internationally. Numerous river basin agreements and the Montreal Protocol, which established rules for use of the atmosphere, took effect after the Stockholm Conference. The recent strength and breadth of international involvement in environmental protection was established financially by the Global Environment Facility (GEF) in 1990 and politically by the U.N. Conference on Environment and Trade held in Rio de Janeiro, Brazil, in 1992 (the Rio Conference). The GEF has already disbursed $1.3 billion through the World Bank and the U.N. Environment Programme. The Rio Conference attracted over 150 nations to the largest meeting ever held to promote international agreement on environmental protection.

Environmental problems attract international concern when production activity in one country affects the environment in another country, or when controls on production activity affect competitiveness among countries. Environmental damage across national borders occurs when pollution damages a neighboring country or the global commons. Localized agricultural examples include runoff of chemicals onto neighboring

[1]The author acknowledges Steve Haley, Barry Krissoff, and Carl Mabbs-Zeno for their extensive contributions to this chapter.

[2]For instance, see the comments, cited in the References, made by Michael Smith, former Senior Deputy U.S. Trade Representative and U.S. Ambassador to the GATT.

countries and the diversion of irrigation water that otherwise would have crossed a border. Global examples include the effect on the atmosphere of land-clearing operations that increase carbon dioxide production and decrease oxygen production. Nitrous oxide and methane are byproducts of agricultural production that could contribute to a longrun warming of the world climate.

Domestic concerns for environmental quality can also impact on global markets for agriculture, fisheries, and forestry. Two very different examples have recently received public attention: the directive of the European Community (EC) to reduce surface and groundwater contaminants through spillover and leaching; and the U.S. restriction on yellowfin tuna imports caught by purse seine fishing nets. Each of these actions represents a government policy to eradicate a perceived market failure--a failure to adequately value an environmental good, namely water quality and animal life (dolphins). Each represents an internationalization of environmental policies. In the EC case, the environmental policy, in effect, limits fertilizer use and implies a change in production techniques, food output, and ultimately, changes in trading patterns. In the U.S. case, the objective of saving the lives of dolphins leads to a trade instrument, also altering trading patterns. Other nations in Europe and Asia also have joined the U.S. boycott.

The shift in international attention to better account for environmental issues inevitably confronts traditional motivations underlying trade policy formation. Trade itself is an instrument for (or means of) enhancing national welfare through maximizing a nation's income and growth potential. Especially since the end of the Second World War, trade has played a large role in motivating international cooperation. Institutions designed to promote or control trade are now adjusting by incorporating explicit environmental considerations. In 1991, the Trade and Environment Group of the General Agreement on Tariffs and Trade (GATT) met for the first time since it was formed in 1971. Trade institutions are motivated in this adjustment both by a recognition of environmental effects of policies designed for trade purposes and by trade effects of policies designed for environmental protection.

This report examines a critical intersection of concerns by focusing on issues that are simultaneously environmental, trade-related, agricultural, and international. It provides articles ranging from the introductory theory underlying policy design to case studies of specific policy reforms. This range is too broad to attempt comprehensive coverage of the topics, but the report is made practical by its convergence on issues of immediate interest: approaches to free trade, European policy reforms, and global warming.

Clarifying the Trade-Environment Nexus

Trade occurs because of its capacity to improve national welfare through consumption of a wider variety of products. The concept or practice of trade and maintaining environmental quality are comparable in the sense that they share the same goal: improved social welfare. The nexus or conflict occurs where economic activity is conducted in such a way or scale as to harm the environment, and where environmental regulations inhibit economic activity, such as trade. Environmental quality, although more intangible, can be considered in several ways, including: something that can be consumed (such as recreation), a more healthful work setting, or the setting in nature in which consumption takes place. In this last sense, a pleasant or nonharmful setting contributes to the utility derived from the consumption itself.[3]

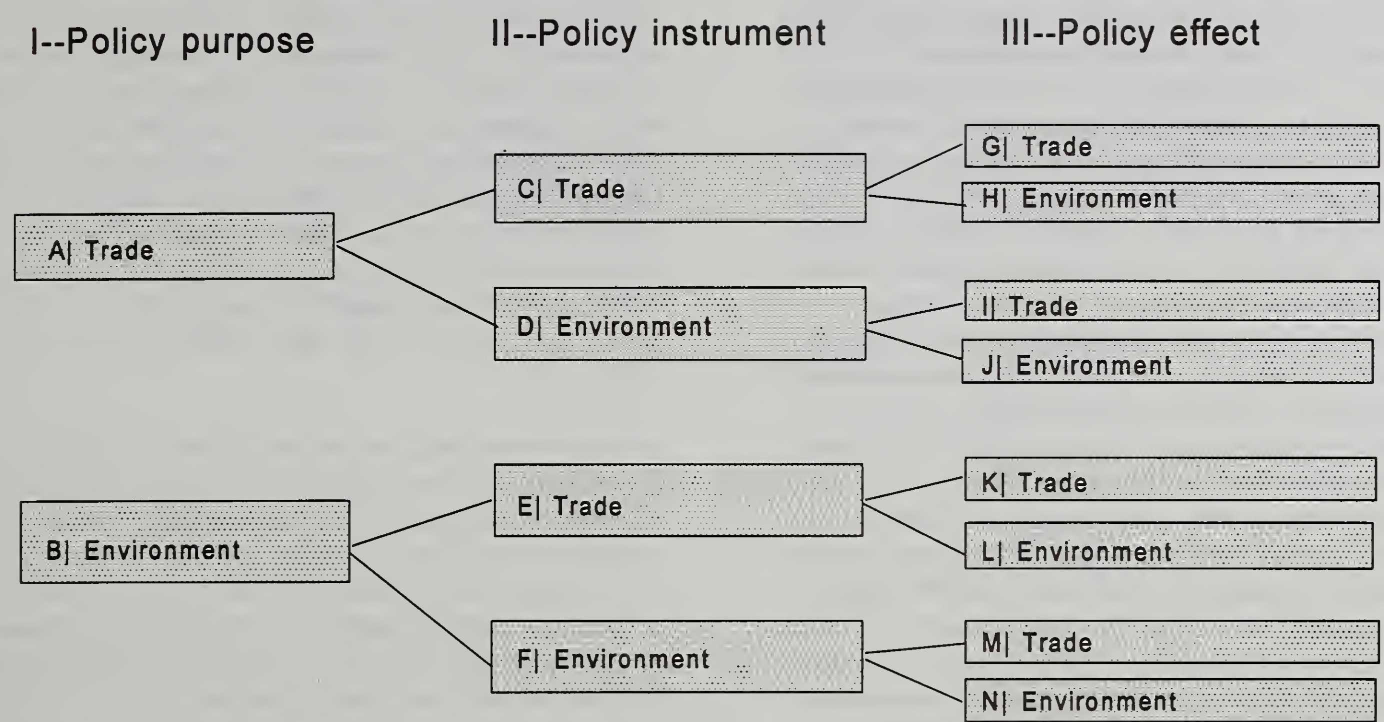
Partially due to these conceptual difficulties, the debate over how to adjust policy for trade and environmental problems has been hampered by ambiguity in the use of these terms. Both terms are used to define policy purpose, instruments, and effects. Figure 1 provides a framework for delineating the issues in the trade-environment nexus.

The first column in figure 1 represents trade and environmental goals, and possible tradeoffs between them. Serving one type of goal often serves the other as well. For example, improved environmental quality might improve agricultural production and trade. In other circumstances, however, there is a tradeoff between trade and environmental goals. Questions then arise of how much loss in environmental quality is acceptable

[3]A conceptual difficulty that has masked the contribution of environmental quality to national welfare has been the lack of accounting for environmental amenities in a system of national accounts (gross domestic product, for example). This topic is reviewed by Beattie in chapter 2.

Figure 1

Trade and environment nexus



for a specified improvement in trade, or how much loss in trade is acceptable for a specified environmental protection. An example of the first type of issue is how much rainforest depletion can be justified by land clearing for soybean exports from Brazil. An example of the second type is how much trade loss can be justified by tighter standards on pesticide residue. The science of economics is silent in judging the relative merits of public objectives, although it can offer tools that facilitate the debate.

While it is widely accepted that freer trade leads to increased economic efficiency and economic growth, these gains neither guarantee improved environmental quality nor necessarily create environmental degradation. The effect of freer trade on agricultural resources and environmental quality depends on several critical factors that include changes in production levels, variable input use, land use, technical change, whether polluting goods are imported or exported, consumed or produced, and whether a country is large enough to affect changes in world prices or is a price-taker. The effect of freer trade also depends on the current conditions of agricultural resources. For a country with a relatively resilient resource base, freer trade could have little impact on environmental quality.

The second column in figure 1 represents the issues concerned with choosing between policies that rely on trade measures and those that rely on environmental controls. Policy instruments based on trade include quantitative restrictions, such as quotas and bans on imports, and price wedges created by import tariffs or export taxes. Policy instruments based on natural resource use include regulatory approaches, such as quotas and bans on pollutant discharge, and incentive approaches like a tax on pollutant emission.

Environmental instruments used for environmental purposes can affect trade and environment quality. Environmental policies and regulations affect cost structure by altering inputs or levels of productivity. The argument that increased costs associated with environmental protection leads to a loss of competitiveness is most often stated in the context that countries with less stringent environmental regulations than others may gain a cost advantage, or that tighter unilateral environmental management on the part of one country places it at a cost disadvantage. In the

long run the fear is that pollution-intensive industries would migrate to less regulated settings.

Cells (A and C) and (B and F) represent relatively straightforward situations in which the policy purpose (trade and environment, respectively) is treated with policy instruments that function in the same sector. Cells (A and D) and (B and E), however, represent situations in which one goal or policy purpose is affected by policies or policy instruments designed largely to meet other goals (trade purpose - environmental instrument; environmental purpose - trade instrument). This raises the likelihood of unintended consequences and complicates the process of policy design. Nonetheless, such policy designs that cut across sectors are common. For example, environmental purposes are explicitly served in the General Agreement on Tariffs and Trade, and in the North American Free Trade Agreement. Trade instruments have been applied to nontrade purposes because they are relatively effective in the demanding task of influencing the behavior of sovereign nations.

The third column in figure 1 represents trade and environmental effects of policies. The trade effects (cells G, I, K and M) constitute the part of trade performance that is influenced by government activity. Similarly, the environmental effects (cells H, J, L and N) constitute the portion of environmental quality that is influenced by the government. This framework distinguishes the uses of "trade" and "environment" in policy analysis and provides some context to the relationship among the articles in this report.

The issues that this report deals with roughly follow three paths through figure 1. The environmental impacts of GATT and NAFTA can be characterized as movement from A to C to H. Trade impacts of the EC Nitrate Directive or a pesticide ban move from B to F to M. Mixed trade and environmental impacts of bans on ivory or tropical forest products follow a path from B to E to K or L. Finally, the possible trade impacts from the use of environmental policies and trade measures such as nontariff barriers might also be traced from B to E to K.

Contents of Present Report

Countries generally pursue trade and environmental policies to augment community welfare or to increase the welfare of a segment of the population. National income accounting is the most often used approach in measuring welfare and gross domestic product (GDP). However, GDP does not tell us about changes in economic welfare, a concept that encompasses both economic goods and bads generated. Tobin and Nordhaus pioneered a measure of economic welfare that includes certain economic bads, such as pollution, litter, congestion, and noise, which are subtracted from GDP. A measure of well-being also may subtract depletion of our natural nonrenewable resources, such as fossil fuels and forests. In chapter 2 of this report, Beattie examines methods for measuring environmental value across an economy. These values are measured without regard to how policies affected them, but the measures are useful in policy evaluation.

Linking environmental value to policy design requires models of human response to policy and ecological response to human activity. Such models and the data to support them are insufficiently developed for analyzing national programs. An approach to explicit measurement of environmental effects from policy is discussed by Mabbs-Zeno and Antle in chapter 3.

Research on policies in various countries benefits from a consistent approach to description of those policies. Policies based on trade instruments have been extensively described and compared in support of various trade negotiations. Policies based on natural resource controls are more poorly documented. In chapter 4, Gray and Vocke provide a typology of country natural resource policies, and illustrate them with country examples. International programs and agreements with environmental purposes are surveyed by Mabbs-Zeno in chapter 5. International trade agreements are further assessed in chapter 6 by Skully, and their design for environmental purposes is examined.

The economic analysis of trade and environmental issues centers on the relationship between purposes and effects of alternative policies. Policy evaluation generally consists of quantifying the effects of a policy and comparing them to the effects of an alternative policy. The basic theory underlying analysis of the trade-environmental nexus is discussed in chapter 7 by Gray and Krissoff.

The next several chapters examine specific cases relating to particular regions. Three papers have a Western Hemisphere focus. Anderson focuses on

the potential environmental effects of a trade agreement among North American countries in chapter 8. Ballenger, Beattie, and Krissoff (chapter 9) appraise the effects of a wider trade agreement in the Western Hemisphere, emphasizing the tradeoff in policy design between trade and environmental goals. Forsythe and Evangelou (chapter 10) examine the trade and environmental effects from alternative means to control pests brought in with imported fruit and vegetables. The motivation for each policy is environmental in that each is intended to protect against agricultural pests. One policy, however, endangers the ozone layer of the atmosphere through its chemical emissions. The policies, therefore, offer a tradeoff between ozone protection and commodity trade.

Empirical studies in this report also examine cases in which the effect of environmental policies on competitiveness is a major concern in the European Community. Leuck (chapter 11) relates a policy with environmental purposes, the EC nitrate initiative, to its production consequences. The following chapter by Haley relates the effect of changes in EC production to trade. Haley also considers scenarios which combine the nitrate initiative with reform of the EC Common Agricultural Policy. This pair of studies demonstrates methods for analyzing a politically important class of issues while addressing a specific case with a large impact on international trade.

In chapter 13, Giordano focuses on Malaysian forest policy. Like Haley and Leuck, he shows that domestic environmental policies can have a significant impact on trade.

Darwin, Lewandrowski, McDonald, and Tsigas (chapter 14) report on the effect of all existing policies on a particular environmental attribute, global temperature, and on the effect of that attribute on agricultural production and trade. In this case, environmental feedback on production allows policy to affect production twice, once directly and again through its effect on the environment.

Together, the articles in this report provide a recent benchmark in economic analysis of agriculturally related trade and environment issues. They sometimes roughly quantify trade effects of policies with environmental purposes or environmental instruments, but they are less specific on environmental effects of trade policies, however defined. Methods and data for analyzing environmental effects, including feedback on production and trade, are demonstrated. Although concern over the trade and environment nexus is not new, the present direction of research offers new promise for quantifiable and reliable policy analysis. It represents a step in the direction of understanding the issues related to trade and environment.

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Chapter 2

Environmental Accounting: Including the Environment in Measures of Well-Being

Rachel Beattie

Unlike most economic assessments of welfare, this paper compares economic measures of living standards across countries, including an evaluation of environmental degradation. Efforts to include price measurements of "environmental depreciation" in the System of National Accounts are detailed, in response to charges that traditional measures of economic growth undervalue the natural resource base and overestimate social welfare.

Introduction

The examination of trade, both current trade patterns and future trade agreements, raises the question of the effect of trade on economic well-being. Most trade research has used conventional measures of economic welfare, such as producer and consumer surplus. Trade also affects income, usually measured by the System of National Accounts (SNA). These accounts typically cover only goods and services that are exchanged in markets while omitting nonmarket-based activities; thus, the accounts may neglect important aspects of welfare. For example, these accounts have long been criticized for excluding nonmarketed labor, such as work within the home or subsistence agriculture. More recently, some have argued that these longstanding measures are faulty because they omit the effect of environmental externalities on current well-being and the effect of natural resource depletion on future well-being.

This paper examines efforts to modify the System of National Accounts with price measurements or nonprice indexes of environmental degradation--efforts referred to as "environmental accounting." Some environmental accounting approaches focus on measuring changes in the natural resource base, such as depletion of fossil fuels or clearing of forests. Other approaches attempt to measure environmental externalities. Examples of these externalities include various types of pollution or contamination that lower the standard of living: litter, noise, toxic waste, air pollution, and so forth. They also include environmental amenities that enhance welfare, such as recreation, national parks, and scenery. Environmental accounting may assist our analysis of trade or economic growth by drawing a more complete picture of economic well-being.

National Income Accounting

The national income accounts originated in the 1930's, influenced by the Keynesian concerns with the business cycle and unemployment. The System of National Accounts, which began in 1942, has several measures of national production: gross national product (GNP), gross domestic product (GDP), net national product (NNP), and disposable personal income (DPI). In the 1946 publication, <u>Value and Capital</u>, Hicks emphasized the importance of net income, writing that it is more relevant than other measures of economic well-being because it represents the amount that society consumes after maintaining society's stock of capital:

> The purpose of income calculations in practical affairs is to give people an indication of the amount which they can consume without impoverishing themselves. Following this idea, it would seem that we ought to define a man's income as the maximum value which he can consume during a week and still expect to be as well off at the end of the week as he was at the beginning. Thus, when a person saves he plans to be better off in the future; when he lives beyond his income he plans to be worse off.

However, net income in conventional national accounts omits the depreciation of several sources of capital. Because of severely underutilized capacity in the 1930's, the Keynesians neglected the contributions of capital embodied in natural resources to a nation's economic welfare. The NNP corrects partially by including the deterioration of such capital goods as plants and machinery by subtracting a yearly depreciation allowance, but does not allow for the degradation of natural resources.

Accounting for Resource Depreciation and Depletion

Environmental economists have attempted to correct the asymmetric treatment of produced capital and natural resources by including accounting for natural resource deterioration and/or depletion. The main efforts at environmental accounting have focused on two environmental effects: changes in environmental quality caused by production (for example, pollution effects) and change in the value of stocks of natural resources (depreciation/depletion). Research in the United States and Japan has focused on the former, while research in resource-based economies (the Scandinavian countries and many less developed countries) has concentrated on the latter.

Two main approaches to environmental accounting have been developed. One group advocates developing an account auxiliary to the existing SNA accounts to monitor physical changes in the environment. These accounts would have a measurement or index of environmental degradation in nonmonetary terms. Another school emphasizes the importance of measuring a price for the environment because that price may simplify comparing environmental changes with other statistics that use money changes. Some would have that monetary account integrated into the SNA to create a measure of "sustainable" national income, while others would maintain a monetary environmental account separate from GNP.

Physical Accounting

The nonmonetary or physical accounting branch of environmental accounting has concentrated on creating separate accounts that map the flow of such physical resources as material goods and energy. The opening balance or stock of goods is recorded as input, and the closing balance is recorded as output. The balance could change due to several factors: degradation or use, natural growth, and/or the discovery of resources or new reserves. In theory these accounts would be thorough in coverage and would show the transformation of natural resources into goods and into pollution. This approach has been attempted in Norway and also in France, which has the most inclusive and ambitious approach: Les Comptes du Patrimoine Naturel ("patrimonial accounting"). In France, the term has a broader application, also including cultural sites. These physical accounts list the sources of environmental goods on one side and the uses of environmental goods on the other side (Peskin, 1991).

Monetary Accounting

Advocates of monetary environmental accounts attempt to estimate prices for environmental goods. In low-income countries these efforts have focused on valuing natural resource depreciation/depletion. The effect of resource depletion in these economies can be significant because many of these countries rely heavily on natural resources for export revenues, employment, and production.

There is concern about the methodology for measuring depletion and the loss in future income due to the depletion. For example, consider the case of an oil-exporting country that is depleting its reserves. Currently under the SNA, 100 percent of the oil sold counts as net income, despite the fact that the reserves are not permanent. Yet, net income as defined by Hicks implies sustainability, and income from the reserves is not sustainable. Some propose the opposite extreme of not counting oil sold as income; instead, they advocate that all profits from depletable resources (such as oil) represent depreciation. However, under that system, a country that never used its mineral deposits (zero depreciation) would have a higher sustainable or net income than a country that did use its deposits (positive depreciation). The second country does get some benefit (income) from the deposits (or reserves) that the first country does not get because the first does not use the deposits. For the first country, the deposits would have no value in the present and in the future. The second country would more accurately have a higher income. (For example, Saudia Arabia surely has a higher net income if it uses its oil deposits than if it does not.) Also, a country that uses a depletable resource may invest the income in a renewable income source and have sustainable income in the future. Hartwick and Hageman (1992) argue that one could sell a mine, for example, and deposit the sale money in the bank to receive an infinite stream of future income.

Under this interpretation, depletable resources represent both income and depreciation. The debate centers on how to measure what percentage represents income and what percentage depreciation. Hartwick and Hageman recommend calculating depreciation by measuring the change in the value of reserves (a mine, in

their example) over time. However, if stock market data on extractive firms are not available, the researchers must estimate the value of the firm, a complicated and potentially controversial exercise.

Hartwick and Hageman describe an alternative approach called the "total Hotelling rent" method. The method estimates the quantity extracted and the profit on the marginal ton to calculate the depreciation. Alternatively, the method advanced by El Serafy (1991) entails estimating the quantity extracted during the current period, the current total profit and the remaining reserves to estimate depreciation.[1]

The Role of Technology and Discoveries of New Reserves

All the methods described heretofore have the weakness that they rely on the current worth of the depletable resource. Future worth is uncertain, however, because technology can change. For example, if in the future, a new technology were developed that made generating renewable energy cheaper than extracting fossil fuels, then oil reserves would have diminished worth as an energy source. Also, new reserves may be discovered that may change the worth of the deposits.

There is the issue of when new discoveries of reserves should be included in income. (In contrast, additions to produced capital, or investment, occur and are recorded in a definite time period.) It could be argued that, if depletion of reserves is considered and subtracted from net income, discovery of new reserves should be included as income in the year of its discovery, with possibly a discounted value of future income flows.

Case Studies Incorporating Environmental Accounting

Robert Repetto and his colleagues at the World Resources Institute (WRI) have focused on depreciation of many types of natural resources (Repetto and coauthors, 1989). In a study on Indonesia, the Repetto team estimated that the annual income growth between 1971 and 1984 was 3 percent lower than if the effects of natural resource depreciation were included. They found that soil losses amounted to 40 percent of the net value of crop production and that net losses of forest resources were actually greater than the value of the timber harvested.

Similarly, Repetto and WRI estimated resource accounts for Costa Rica between 1970 and 1989, examining three "renewable" resource sectors: forests, fisheries, and agriculture. Combined with mining, these resource activities accounted for 17 percent of the national income, 28 percent of employment, and 55 percent of export earnings. They calculated the present value of potential future rents by discounting the value of the stream of future income and subtracting costs. The costs of soil nutrients, decline of fishing species, and loss of timber were measured, using marketed costs.

Their calculations show that the Costa Rican economy suffered a loss of 1 year's worth of GDP during the 20-year period due to natural resource depreciation. For example, in the case of forests, they subtracted the loss of forests (cleared for agriculture and for timber) from the gain in secondary forests to get net change in timber. In 1984, they calculated that the value of forests loss was $167 million, amounting to $69 for each man, woman, and child in Costa Rica. Much of the forest cleared is for agricultural use or for pasture, although often the land is not well suited to grazing.

Likewise, fish reserves experienced a net negative depreciation in the 1980's. Fisheries in the Gulf of Nicoya typify a "tragedy of the commons" as they have been depleted far beyond the economic optimum. For example, between 1985 and 1988, the quantity of white shrimp declined 70 percent and fidel shrimp declined 90 percent; and between 1975 and 1987 sardine production declined by 91 percent. It is difficult to measure the maximum sustainable yield because yields fluctuate naturally with weather, currents, and so forth. With limited fishing, the fish reproduction rate increases, but with more intensive fishing, the fish may have a lower population size and may even decline until no fish are left. The Repetto team estimated the fisheries' sustainable yield, based on a measure of "fishing effort" (or intensity), and recorded yield, finding maximum sustainable rents occurred in the early 1980's. The total loss between 1981 and 1989 in potential income was estimated at about 2,240 million colones. Although worth less than 1 year's loss in soil erosion, the loss is large compared with the size of the fishing sector.

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[1]For a more detailed examination of these methods see Hartwick and Hageman (1992), pages 330-33.

To estimate erosion and soil loss, the Costa Rican study uses a Universal Soil Loss Equation. Assuming that soil loss can be replaced with agrichemicals, the study approximates the onsite cost of soil loss with the cost of replacement fertilizers. The offsite costs included loss of reservoir capacity (difference between real value with sedimentation and value with designed useful life) and increases in flooding capacity. They found a fairly steady depreciation of about 2,600 million colones per year between 1970 and 1989, amounting to about 9 percent of value added in agriculture.

The Costa Rican example illustrates how Government policies may encourage economic "growth" while overlooking resource depletion. Government policies have encouraged the expansion of agriculture through tax incentives, subsidies to the beef industry, and land tenure laws that emphasize "improving" land for legal title. Likewise, the Costa Rican Government has encouraged fishing through offering such incentives as tax forgiveness on inputs and preferential fuel prices. Environmental accounting might help alert policymakers to environmental problems.

Valuation of Nonmarketed Environmental Goods

Most of these developing-country environmental accounting studies examine only the marketable costs of depreciation and mineral deposit extraction, and not other nonmarketed environmental goods (or externalities) such as esthetic value, biodiversity, or pollution. In industrial nations, however, natural resources constitute a much smaller percentage of annual production than in developing countries. Thus, efforts at environmental accounting in these countries have tended to focus on measuring environmental byproducts, such as water and air pollution.

Measuring the worth of many environmental goods is complicated because either they are not exchanged in the market (such as endangered species) or the market costs do not reflect the true costs (such as hospital bills for lead poisoning versus the full cost of the illness). Thus, it is difficult to estimate how much people value them. Currently, environmental and resource data tend to be inconsistent across large areas and difficult to integrate with other data sets. Methods currently in use to measure environmental goods include direct and indirect approaches.

Direct valuation methods entail using prices of activities related to the environmental problem. For example, environmental contamination may lead to health problems, sickness, and premature death. Although morally it may be difficult to assign a value to a human life, one can measure some associated costs, such as medical expenditures, loss of earnings from absenteeism, and early death. Another example is how environmental changes to a resource may lead to productivity changes that can be measured, such as a decrease in fish catch due to pollution or an increase in dairy output due to a tree windbreak (cuts down on cow illness). Another method of direct valuation is the examination of defensive or preventive expenditures (home water filters, for example). Because direct valuation methods cover only expenses that can be measured and not nonmarketed costs or benefits such as the esthetic value of a clean lake, they are seen as a minimum valuation of costs, or, in other words, a lower bound.

Indirect valuation approaches try to provide a better estimate of the value of environmental goods. Some address nonmarketed costs using "surrogate" market values: they are based on the substitution for the environmental good of a good whose value can be measured, or in other words, a marketed good is used as a proxy for a nonmarketed good. For example, one could measure the cost of an artificial fish nursery to replace a wetland (Tisdell, 1993).

Contingent Valuation

Another indirect method, called contingent valuation, uses survey methods to estimate how much respondents value an environmental benefit. Survey methods involve two approaches (Pearce and Turner, 1990; Bishop, 1990). The first one is asking people to say how much they would be willing to pay to have a particular environmental service or to prevent a particular environmental degradation. The second is asking how much people would be willing to accept as payment for an environmental loss or for forgoing an environmental benefit. Although, theoretically, the willingness to pay or to accept would be the same, they differ in empirical tests. It has been found that people view differently losing an environmental amenity which they already have and gaining an environmental amenity which they do not yet have (or have not had recently.)

The main drawbacks to contingent valuation are potential biases. One bias is a "starting point" bias, which results from how a respondent is asked to choose among a range of options. Asking whether someone would pay between 0 and $200 or asking 0 and $100 may lead to different valuations, even if no one bids over $100. Another example is a "hypothetical bias," which arises because respondents never actually have to pay the money, and thus, may inaccurately estimate how much they would choose to pay.

Peskin's Synthesis

Another approach, forwarded by Henry Peskin, which he calls the "neoclassical" framework, attempts to include both direct and indirect costs (Peskin, 1991). He uses direct valuation techniques such as those cited above, examining costs to protect a resource. Then, he adds the mostly nonmarketed costs of any "denial of access to an environmental asset" due to pollution or degradation. In other words, other users of the asset suffer a burden if it deteriorates in quality. For example, people bear a cost from recreation losses or fishing losses in a polluted lake. The main weakness to this approach is that it relies on imprecise monetary measurements of lost benefits.

In addition to the three conventional sectors under the System of National Accounts--government, industry, and households--Peskin's accounting framework adds the environment or nature as a fourth. The adverse effects from resource degradation are treated as negative output within this category (even though industries, households, and governments may be the injured parties) and environmental services are treated as positive output. Peskin argues that this environmental account could be added to the conventional Net National Product.

A preliminary Environmental Protection Agency study on the Chesapeake Bay used the Peskin framework in an attempt to account for air and water quality, as well as the value of recreational activities. The region included Washington, DC, and the counties in Maryland and Virginia that border the Bay. The study used Bureau of Economic Analysis data from the U.S. Department of Commerce on gross State product to estimate the gross county products that form the basis of obtaining a gross "Chesapeake region" product. Physical measures of water quality (nitrate and phosphorous deliveries into the Bay) and of air quality (based on measurements from the National Acid Precipitation Assessment Program) were used. Survey methods (contingent valuation) were used to estimate the value of recreational activities such as hiking, hunting, and water sports.

The study found that in 1985 the total gross product (similar to GNP) for the "Chesapeake region" was $142.5 billion, and the net product (similar to NNP) was $125.3 billion. The environmental damages to the air were estimated to be $110 million, and to the water were estimated to be $347 million. Net environmental depreciation was calculated to be $78 million. The estimate of final consumption of nonmarketed environmental services was a positive $1.1 billion. Thus, the net change from the environmental sector was environmental benefits minus environmental damages and depreciation. The value was a positive $568 million, making the modified net product $125.9 billion.[2]

In contrast to the Peskin approach, Den Butter (1992) argues against including environmental measures into the GNP, because the net income figure might obscure how sustainable any growth is: "A 3-percent growth of the green GNP can, for instance, either be the result of a 5-percent growth of actual GNP and 2 percent additional pollution or a 1-percent growth of GNP and a reduction of environmental damage by 2 percent." He advocates creating a separate, nonmonetized index of environmental quality that could be used in making policy, similar to measures of unemployment, price stability, balance of payments, and economic growth.

Conclusion

In all of the environmental accounting approaches, most of the work has been theoretical; few full environmental accounts for any nation have been developed. If a standard environmental accounting approach were developed and applied, a primary benefit would be the creation of a more accurate picture of wealth and income. This set of measures could be used with other economic indicators and statistics to make comparisons across countries and across time. A drawback is that environmental accounting does not explain how the environment and economic growth cause or affect each other, nor does it describe how to counter an environmental problem. The availability

[2]In this example, the benefits from the environment exceeded the environmental losses, although many environmental problems were not included, such as solid and hazardous wastes and loss of biodiversity.

and use of these measures, however, could aid policymakers in identifying environmental problems and in designing policies or institutional frameworks that provide for more environmental amenities.

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Chapter 3

Measuring the Impact of Government Policies on the Environment

Carl Mabbs-Zeno and John Antle

Analyses of the impact of government support policies on agriculture have benefited from the development of quantitative measures like the Producer Subsidy Equivalent (PSE), but this measure doesn't account for costs and benefits of policies associated with the environment. In this paper, a theoretical basis is laid out for quantifying the environmental impacts of policies designed principally for agricultural purposes. While much work would need to be done to put this theory into practice, it serves as a useful starting point in devising a practical measure for policy analysis.

Introduction

A surge of international interest in environmental problems has raised the demand for research on agricultural and environmental policies and their economic and other effects. For example, a Federal judge ruled in June 1993 that the President must have an environmental impact statement prepared on the draft North American Free Trade Agreement before it could be ratified. The ruling, however, was subsequently overturned. Such research, however, is hampered by the complexity and poor documentation of the relationship between policy and environment (Bishop and Ervin 1992). This paper presents a conceptual framework and identifies some of the research needs for quantifying the effects of policies on the environment that are designed principally for agriculture.

Problems in Environmental Policy Analysis

Analysis of environmental policies is hampered by the difficulty of quantitatively modeling or assessing policy reforms. Quantitative evaluation of environmental policies suffers from:

(1) inadequacy of data describing the environment, and

(2) poor correlation between available measures of policy level and environmental quality.

The global set of databases on the environment is being expanded by several international agencies, using a variety of strategies. The environmental monitoring programs of international organizations were recently surveyed by the U.N. Environment Programme (Fritz 1990). Most data efforts compile existing data (World Resources Institute (WRI) 1992; World Bank 1992, pp. 196-205; Organization for Economic Cooperation and Development (OECD) 1991; U.N. Environment Programme (UNEP) 1990b). Others actively measure the environment themselves (UNEP 1990a, Fritz 1990). Still others have programs to encourage countries to expand efforts at measuring their internal environmental changes, such as the country reports submitted to the U.N. Conference on Environment and Development and the World Bank's encouragement of National Environmental Action Plans (Falloux and coauthors 1991). The national data collections are separable into natural resource accounts and state of the environment reports (Friend and Rapport 1991).

The global set of databases on policies with environmental purposes consists of a less systematic collection of items compiled in the course of developing the environmental data. Policies affecting agriculture are described for most countries by the Economic Research Service (ERS) (1988). The effects of these policies on production and consumption are also measured for many countries by ERS (Webb, and coauthors 1990) and the Organization for Economic Cooperation and Development (OECD 1992).[1] Descriptions of environmental policies globally are being compiled by ERS (1992) and by the U.N. Conference on Trade and Development (UNCTAD 1992). The first stages in an inventory of policies affecting the environment have been undertaken by the Agency for International Development (USAID 1992).

Analytical tools linking policy to environmental effects are less practical than those linking policy to agriculture, trade, or many other effects that

[1]Both the qualitative and the quantitative inventories of policies affecting agriculture by ERS are being updated.

Figure 1
Relating agricultural and environmental production levels

Angle "pr" determined by price ratio of inputs

are simpler to measure than the environment. The geographic information systems offer new technology for integrating the variety of data used in environmental analysis, but these systems have not yet contributed substantial insights for policy design (Fletcher and Phipps 1991).

Conceptual Structure of Model

While data quality is a concern in all research, it is particularly problematic in analysis of environmental policy effects because existing models generally require data that is unavailable in most countries.[2] The purpose of the conceptual model presented here is to define measurable relationships between policies and environmental quality. It is structured to compare indicators of agricultural output and environmental quality under observed or simulated policy regimes to a hypothetical regime without policy intervention.

The connection between policy elements and model outputs requires specification of production functions for each agricultural and environmental product. Figure 1 represents a case having one agricultural product (corn), one nonvalued, environmental product (productive capacity), and two inputs (fertilizer and land).[3] The upper-right quadrant and lower-left quadrant display the production functions for both inputs with respect to corn and productive capacity, respectively.

The production functions appear as a set of isoquants tracing the combinations of inputs that yield a specified level of output. The price ratio between inputs determines the expansion path along which agriculture operates and the output level is determined exogenously. The resultant levels of input use are then reflected onto the environmental product function to reveal the level of environmental quality. This exercise is done once as a baseline assuming no government policy, that is, all markets are open. Then the exercise is done under a specified policy regime and the output levels are compared to the baseline.

The model is designed to represent an environmental quality response to various inputs simultaneously. Changes in the use of an input typically imply adjustments in the use of other inputs. The effect on environmental quality follows from the new input mix. The environmental production

[2]Environmental policies, as used here, refer to all policies affecting the environment.

[3]Productive capacity as an attribute of environmental quality is discussed later in this chapter.

function represents a particular environment with specified vulnerability to changes in inputs. The functions may not describe another environment facing similar policy alternatives.

Various policies perturb the model in various ways. The production function for corn might be altered by a constraint on technology, like deep plowing. The price ratio for inputs might be altered by use-value taxation of land or a subsidy on fertilizer. The quantity of corn produced might be altered by an export tax. The production function for productive capacity might be altered by discovery of a higher yielding variety of corn or by encouraging cover crops on fallow land.

Model Output

The model suggests the effects of policies on agricultural output and environmental quality. This formulation explicitly renders tradeoffs between agricultural production and environmental quality. Three types of output are produced:

(1) value of agricultural products,
(2) value of certain environmental products,
(3) level of other environmental products.

Agricultural output is estimated for each commodity and each nation according to the monetary value of production under the policy regime being investigated. The sum of these values can be compared with the value of production in an open market to measure the policy effect on agricultural production. This is a conventional policy-modeling exercise.

The value of environmental products cannot usually be convincingly reduced to a single number. Some, like recreational use, can be valued through well-established methodologies. Others, like biodiversity, have not been effectively linked to a monetary value. Those that can be valued are treated in the present model as agricultural output is treated and then added to agricultural output, yielding net effect of policy on all products that can be valued in monetary terms.[4]

The list of potential environmental products is long, but its analysis is made practical by identifying a few environmental attributes that effectively represent all remaining products. The effect of policy on these attributes is measured in terms of the attribute without reference to monetary value. For example, biodiversity under the Endangered Species Act might be measured in terms of the number of species on earth, and compared with the number of species likely without the Act. The challenge met by the present model is to limit the list of environmental products to a useful number.

The set of nonvalued environmental products used by the model should contain few enough elements that a policymaker can simultaneously grasp the tradeoffs among all of them. It should also be comprehensive, so that all environmental effects are represented. Each element should describe unique environmental attributes, so there is no redundancy to complicate the policymakers' evaluation.

The problem of specifying parameters for environmental effects, whose value is difficult to measure, adds to an already lengthy list of such parameters. In addition to the value of output, policy effects include risk, equity, timing of returns, and other effects on social welfare.

Policy analysts might utilize some imprecisely estimated social utility function in order to balance these effects. This is rarely effective with policymakers, who are skeptical of weighting schema for social goals. In a particular problem, however, analysis may be facilitated because some of these are found to be unimportant. For example, the available policy options may have the same impact on output and differ mainly in the risk they pose. If the list of parameters is short, and easily understood and transparently linked to concerns of policymakers, a formal procedure for aggregation may be unnecessary. The analyst offers enough information for policy decisions by showing the tradeoffs associated with policy alternatives.

It is proposed here that five areas should be addressed: biodiversity, global temperature, human health, productive capacity, and maintenance. Table 1 lists several environmental problems related to each of these five categories. The selection of these categories carries the assumption that they will, in some way, be compared with each other and to agricultural output outside the model. The categories were also selected to be measurable with available data.

The table also suggests units for measuring each environmental attribute. These units are suggestions that can be accepted only after effective use in empirical study. They generally

[4]The components of environmental quality that can be monetized are discussed by Beattie in chapter 2.

Table 1--Policy effects on the environment

Attribute	Potential effects of agricultural policy	Measurement unit
Biodiversity	Habitat destruction for agriculture, pollution of wildlife habitat, risk from promulgation of few genotypes	Number of endangered species
Global temperature	Methane production from cattle and rice farming, forest clearing for agriculture	Global CO_2 level
Human health	Pesticide residues on food, worker safety, water quality	Life expectancy change weighted by number of people affected
Productive capacity	Erosion, fertility loss, desertification, nonagricultural production processes (forestry and fisheries)	Value producible by best use best use immediately after fully instituting policy, without cost of adjusting to best use
Maintenance	Irreversible parts of productive capacity loss	Average annual change in productive capacity following adoption of policy

are used to compare a part of the environmental situation under a specified policy, whether present, past, or prospective, with the open market situation.[5]

Biodiversity

Biodiversity can be measured by the number of species in the world. Therefore, the policy effect can be measured as the number of species with the policies compared with the number under an open market. This measure could be strengthened by accounting for risk, perhaps by adding the difference in number of endangered species in the two policy regimes. It fails to account for the risks from monocropping, although they might be captured by open market studies if sufficient information were available.

Global Temperature

The contribution of a policy to global temperature could be represented by global CO_2 level. This is the main "greenhouse" gas associated with agriculture. A policy with known effects on deforestation, rice production, and cattle production could readily be expressed in terms of effect on global CO_2. Policies whose main effect is on methane production, for example, could be expressed on CO_2 terms, based on the relative contribution of methane and CO_2 to global warming.

[5]The open market is used as a point of comparison because it is well understood, and is often approximated by observable experience.

Human Health

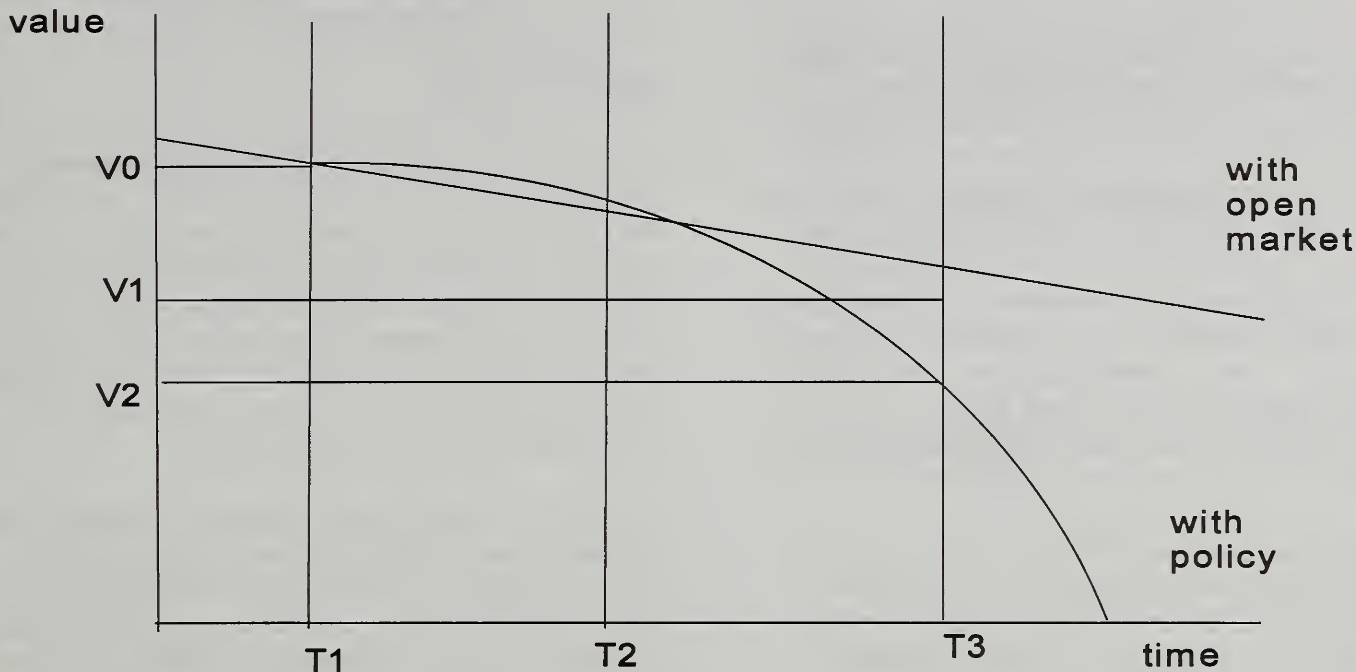
The effects of a policy on life expectancy within a country can be measured. This is biased, however, toward policies affecting younger people and mortality. It may also be possible to obtain measures of mortality or morbidity more directly associated with agricultural activities and policies, such as cases of pesticide poisoning or cases of water-borne disease.

Productive Capacity

Productive capacity is the central interest in evaluating agricultural policy effects. For the purpose of environmental impact, it must be distinguished from the effect of policy on production quantity. It should not, then, be interpreted as how much would be produced with the policy in place compared with how much would be produced in an open market. That is not an essential environmental concern. Rather, this measure should report the ability of natural resources to contribute to production under a specified policy compared with an open market situation.

The actual level of production need not correspond to the capacity. It might differ due to other policies, inefficiency, capital constraints, and so forth. For example, with a land set-aside program, production falls and the production of the Nation is lower as long as the program is retained. Productive capacity, however, in the sense of what could be produced under the most productive

Figure 2
Policy effect on maintenance



practices, is not lost on the set-aside land. Under another policy, capacity might fall due to intensified farming on the land in use. Again, actual production does not correspond to productive capacity.

In theory, capacity depends on frontier production functions for the commodities that could be produced and the selection of commodities to produce. The concept can be made operational by measuring the maximum value of production possible after a policy is in place with technology and prices constant, except as affected by the policy. The price ratios among commodities determine the ratio of production while total production is constrained by resource availability.

Maintenance

Maintenance refers to the change in productive capacity that occurs after a policy has been instituted. It is the dynamic associated with productive capacity and, thus, must be expressed as a flow in contrast to the stock of productive capacity. For example, a policy that exacerbates erosion might not reduce productive capacity immediately in an area with substantial soil reserves. Eventually, however, capacity would decline.

Maintenance and productive capacity are distinguished in figure 2. Two paths through time are shown for productive capacity. The open market is shown to result in a steady decline in capacity as some productive element of the environment degrades. For example, soil depth might be steadily declining through erosion, constraining the root zone. The policy under study is introduced at T_1. It initially raises productive capacity (T_2), but eventually reduces capacity even below what it would have been under an open market (T_3). In the example, this might occur with introduction of tractors on a tropical soil. At first, the machinery deepens the root zone, offsetting erosion, but eventually it damages the soil through compaction. Productive capacity was raised relative to the open market, observed shortly after the policy took affect. Maintenance was lowered since the changes in expected value of productive capacity were more negative with the policy than with the open market.

This set of nonmonetized environmental attributes encompasses most of the major effects on the environment that currently concern policymakers. Health issues cover the main externalities that cannot be convincingly monetized.[6] Global

[6]Externalities are effects that producers or consumers impose on others without opportunity for compensation.

warming and declining biodiversity are the main transboundary effects of national policies at a global level. The other two attributes represent the quality of the environment in producing commercial services. Productive capacity represents the stock of capacity while maintenance represents changes in the flow of services.

Comprehensive coverage of relevant policy effects remains a problem in this framework mainly because the measures of environmental attributes are weak rather than because there are too many attributes. As more data are collected and as better methods for relating various aspects of an attribute to the same measure are developed, the coverage of the model will improve. For example, human health and longevity are affected by the environment. The correlation between these might be better understood with better data, leading to a better measure of health than the simple life expectancy measure recommended here.

Redundancy among the attributes listed remains a problem because components of nonmonetized environmental attributes are measurable in monetary terms. For example, in studying a particular country, the monetized products might include agricultural output and recreational value. If an endangered species living in area contributes to recreational value, the policy effect on recreation must be carefully distinguished from the effect on nonmonetized biodiversity.

The short length of this list is a tribute to the effectiveness of the science of economics in placing values on externalities, although the presence of the list at all is a recognition of the limitations of valuation exercises. It should be possible to effectively represent the circumstances of each country without losing comparability with studies of other countries.

Research Needs

To apply the model, the relationships between input and products must be specified. Agricultural production functions are often estimated for policy analysis. Environmental production functions are occasionally used, but the measure of environmental quality varies widely. The major gaps in existing knowledge for use of this model are the production functions for specific, non-monetized environmental services.

A set of environmental production functions could be determined without reference to a specific policy question, but the task of assessing the vulnerability of each country in the world to five components of environmental quality would be daunting. Rather, the experience gained from ongoing policy analysis might be eventually collected, and a classification of countries into categories of similar vulnerability might be used to build a global model. If policy research adopts a consistent set of policy measures for environmental effects, as suggested here, the task of comparing experience in various countries would be enhanced.

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Chapter 4

Policy Choices in the Use of Land and Water

Denice Gray and Gary Vocke

The objective of this paper is to describe through country examples (1) allocative systems that determine who can use the land and water resources, (2) public control or influence over allowed uses of these resources, and (3) public protection of these resources. This paper describes the allocative systems and public policies affecting resource use of various countries. These systems and policies differ for many reasons, including history of the country and scarcity of the resource. The systems and policies that have evolved for land and water are different because land stays in one location while water flows from one location to another, and because of the uncertainty of the water supply.

Introduction[1]

As mentioned in the introduction to this report, natural resource policies to manage land and water are environmental instruments with both environmental and trade effects. How land and water resources are managed influences agricultural production around the world and, hence, trade among countries. For example, policies to expand irrigation can increase yields and production. In Indonesia, the development and upgrading of public irrigation projects for growing high-yielding rice varieties quickly moved the country from being the world's largest rice importer to self-sufficiency. Policies to manage agricultural practices to protect land and water quality can also affect production and trade. For example, the U.S. Conservation Reserve Program, which had environmental improvement as a primary objective, took highly erodible and environmentally sensitive cropland out of production, reducing the availability of grain for export.

Land and water are crucial inputs into agricultural production. These resources also have many competing uses in other sectors of the economy, including scenic beauty and wildlife habitat. Societies have developed various means to allocate land and water resources among the many competing uses, and to change that allocation when needed. Allocative systems are the means by which individuals or entities become resource users. For example, many countries allow private ownership and transfer of land; thus, one can become a land user by buying the land. On the other hand, in some countries the water belongs to the state, and one can only become a water user by receiving a permit from the state. The state has an interest in the specific uses made of these resources, as well as in the prevention of excessive resource degradation. Governments can achieve public goals concerning land and water use through state ownership, mandatory controls, economic incentives, or economic disincentives.

Systems of Allocative Rights for Land and Water Use

Systems of allocative rights define legal uses of the resource, owners of rights, rules of transfer, and length of tenure. Property rights affect both economic and environmental incentives. That is, the level of control over the resource by users determines the extent to which users employ the resource efficiently, invest in conservation, and maintain quality.

Land Tenure and Transfer

Land tenure systems range from complete state control over land use, to shared control by communities, to complete control vested in individual owners. Land allocation systems are illustrated below with four examples of land tenure and transfer rules. The first example (Zambia) describes a country in which there is no fully private ownership of rural property. Two examples (Brazil and Thailand) describe the conversion of state-owned property into private property. The fourth example presents a country (Japan) with large areas of private property, although owners face restrictions on the transfer of private property.

[1] Most country examples are drawn from two forthcoming ERS publications, Global Review of Resource and Environmental Policies: Land Resource Development and Management, and Global Review of Resource and Environmental Policies: Water Resource Development and Management.

In Zambia, no individual ownership of rural property exists. Rather, Zambia has four major categories of land tenure, one controlled by the state and three managed through traditional tenure systems (Mabbs-Zeno). State land includes areas without specified use, land used by the Government, and property leased by the state to individuals and corporations. The Commissioner of Lands has the authority to grant leases. Leases usually require a specified use of the land and particular improvements. Authorities charge an annual "ground rent" for each lease. Urban fringe areas face greater restrictions and authorities charge a property tax on urban land. The Commissioner of Lands approves transfers of leases. The Valuation Board approves the price of the transfer and levies a tax of 5 percent of the transfer price. Transfers of farmlands further require the approval of the Agricultural Lands Board.

The three traditional forms of land tenure in Zambia have their foundations in systems that arose on tribal lands--lands reserved during the colonial period for indigenous people. On Lozi land, the paramount chief is the ultimate owner, but he allocates effective land titles to his family members and to subchiefs, who in turn distribute the land to tribal families. Tenure on "family land" is very secure, while rules loosely define the inheritance system. On Ngoni land, chiefs have substantial authority over land allocation. Chiefs must approve the cultivation of unused land, and unused land reverts to the chiefs. Rules detail a clear line of inheritance. On Tonga land, and land of many other tribes in Zambia, chiefs have less control over land allocation than under the other two tribal-based systems. Although cultivators must still obtain permission from the chiefs to clear unused land, the farmer retains control over cleared land if he uses it continuously, or if it becomes idle in a land-abundant area. Land transfer or sale to a relative or friend is common. Rules describe the procedures for inheritance of land, although the farming skills of potential heirs can influence the decision.

In contrast to the state and communally owned systems in Zambia, the Government of Brazil sought to privatize State-held lands. From the 1960's to the early 1980's, the Government of Brazil enacted policies to develop the Amazon Basin. One of these policies was the provision for the privatization of public land (Barnard). In order to claim, hold, or sell untitled land, Brazilian law declared that settlers had to clear one half of the area claimed. A migrant who lived on and improved the land received a preference in obtaining title to up to three times the area cleared. The Government considered forest clearing and conversion to pastureland evidence of land improvement. After migrants obtained a clear title, they could apply for tax credits, land concessions, subsidized credit, and subsurface mineral rights. Their chances of obtaining neighboring timber and mineral wealth also increased. These land tenure policies encouraged agricultural expansion into rainforest lands and promoted deforestation. In the early 1980's, the Government dismantled some of these policies in order to promote environmental goals.

In Thailand, legislation imposed state ownership and created reserves on a large portion of the national lands (Feder and Onchan; Feder, Onchan, and Chalamwong). Legislation in the 1960's classified half the total area as national forest reserve land. However, illegal squatters cultivate about one-fifth of the forest reserve; their cultivated land also accounts for one-fifth of the cultivated land in the country. These squatters are incapable of obtaining clear title to the land, even though some have cultivated the land for more than 15 years. However, there is a very low eviction rate, so squatters tend to consider themselves owners of the land. Although selling or buying forest reserve land is illegal, trades involving reserve lands occur as often as those involving private land. Squatters even pay land tax on their untitled land. The primary disadvantage of untitled land to Thai farmers is that they can less easily obtain institutional credit. There is an implicit preference for borrowers with secure ownership, since untitled land can't be used for collateral.

In 1981, in an effort to enhance the ownership security of squatters, the Thai Government began a program of issuing certificates that grant rights of limited use to squatters on forest reserve land. While the backers of this policy hoped that the certificates would enhance access to institutional credit and stop further deforestation, others have suggested that the certificates are inappropriate mechanisms to increase availability of institutional credit because they do not grant a clear title to the land.

In large parts of the world, private ownership of rural land predominates. Rural private property is the major tenure system in North America and Europe, for instance. While owners of privately

held land have a large bundle of rights attached to their land, in various countries there are restrictions on land uses and rights of transfer, as well as incentives to control behavior.

Japan has a number of policies that discourage the transfer of privately held agricultural lands (Webb). The Agricultural Land Law of 1952 limited landholding in most of the country to 3 hectares, placing a barrier on the consolidation of agricultural land. Although amendments to the Agricultural Land Law in 1962 removed the 3-hectare limit, other regulations and tax laws constrained land transfers. Japanese regulations divided farmland into three categories for purposes of transfer. The sale of urban farmland faces no restrictions. For "intermediate land," land generally on the fringes of urban areas, the governor of the prefecture must approve land transfers to nonfarm residents or for nonagricultural uses. Finally, rural farmland can be transferred only to another farmer who will sustain its agricultural use. Taxes on farmland are much lower than those on residential land. Capital gains treatment and inheritance taxes also favor land that remains in agriculture. These regulations increase the costs of transfer of agricultural land, resulting in most of the farms remaining under 5 hectares.

Water Allocative Systems

Unlike land, water is a mobile resource. Water flowing down a river has potential users all along its course, with upstream users having first chance to divert the water. Underground water also moves. As underground water is pumped by a user, the nearby water flows to the point of extraction. Water can be transported by canals or pipes to users far away from its point of diversion or extraction. Water can be stored, for example, in a dam supplying water to irrigators. Finally, in contrast to land, there is the uncertainty of the supply of water due to rainfall fluctuations.

The purpose of this discussion is to illustrate through country examples how individuals or entities gain the right to use water for agriculture. These water-rights examples include discussions about South Africa and the United States, where water use rights are obtained by acquiring adjoining land. Then the examples of the United States, Denmark, and Chile are presented where, in each case, water is treated as a separate resource. Large irrigation schemes are special cases of water allocation systems that coordinate water use among many irrigators. The Government's direct role in Indian irrigation schemes is first discussed. Then, user management by the irrigators themselves in Spain is presented.

South Africa classifies water sources as either public or private, which determines who can use the water for what purpose. Public water is any water in a natural stream that can irrigate two or more pieces of adjoining land. Generally, public water may be used only on adjoining land. The quantity of water that can be extracted depends on the use. Adjoining landowners may exhaust the normal flow of a public stream for domestic uses only. Landowners have the right to use a stream for agricultural purposes as long as they do not prevent downstream landowners from having water for domestic purposes. Private water in South Africa includes: spring water, rain water, drainage water, water of private streams, and underground water. The right to use private water belongs to the owner of the land on which the water is found.

The United States allows each State to develop its own water allocation system. In the humid, eastern half of the country, where water is abundant, some States have legal systems for surface water that provide an equal right to all landowners bordering a watercourse to make reasonable use of the water. Thus, the right to use water is tied to acquiring land. This water-use right is to be held safe from harm by others making unreasonable uses of the water. Courts determine whether a particular use is reasonable after a dispute is brought before them. Thus, reasonable use is always subject to reevaluation by the court when circumstances change.

The Western United States did not develop surface water legal systems tying water-use rights to land adjoining the watercourse. Water was relatively scarce in the West and there was also the issue of irrigating lands that did not border the water bodies. The Western States developed a legal system under which the State authorizes use of a fixed amount of water if the water is diverted and put to beneficial use, regardless of where the use is located. When all the water has been allocated in this way, no additional users are allowed. Importantly, the earliest water right on a given watercourse has preference over later users. Thus, this priority of earlier rights becomes the basis for dividing water among the water users during periods of scarcity. Prior users can divert

the entire quantity of water right before later water users can divert any water at all.

In some countries, the state directly decides how the water will be used. In Denmark, for example, regional authorities and municipalities decide the priority among water users and license them accordingly. They grant water extraction licenses for agricultural use for a maximum of 15 years for groundwater and 10 years for surface water. In Chile, the Government-granted right to use water is an asset that can be marketed. Thus, with some limitations, the users themselves through the marketplace determine the allocation of the water.

The coordination of water use among many irrigators in large irrigation schemes can be by the state directly, or by some organization of the irrigators themselves. For example, in India the construction and operation of large irrigation projects is the responsibility of State governments. There is no nationwide procedure of allocating this water to farmers in public irrigation systems. In northern India, farmers typically expect to receive canal water in proportion to landholdings, which they can use as they wish. In mid- and south India, the Government rations irrigation water among the irrigators based on a cropping pattern that is also determined by the Government. Water delivery is by fixed rotation with no adjustments for changing water requirements as the crop grows.

In contrast to India, irrigators in Spain form water communities for managing water for irrigation. Water communities are independent organizations. They can impose fines, assess taxes to cover operating costs, and create ordinances. In some communities, every member has just one vote in decisionmaking. In others, large landholders have more votes than small landowners. Some communities allocate water to irrigators in proportion to their landholding in the irrigation scheme. Other communities have a water market where water rights can be sold among members. Communities also have different procedures for rationing water among members during severe droughts.

Changing conditions can induce countries to change their allocative system. For example, if rising demands threaten to exhaust water supplies, the public may intervene by developing a new system that allows the Government to limit water extraction. Sometimes public objectives change, for example, making efficient use of the water more important. This change of public policy objective can lead to a change in the water allocation system. Israel, Spain, and Australia are examples of allocation systems that changed as circumstances changed.

In 1959, Israel passed the Water Law that refuted existing private water rights to water sources that were based on previous Ottoman and British law. Water sources were made public property under the control of the Government. The Ministry of Agriculture is responsible for allocating water supplies to urban, industrial, and agricultural users through a licensing system.

In 1985, Spain passed a new water law, placing all water in the public domain. Under the old water law, only surface water was in the public domain. In 1985, accommodations were made for existing owners of underground water. These prior owners had two choices. They could maintain ownership of their water for 50 years and then receive an automatic concession from the Government for an additional 75 years. The alternative was that they could retain their ownership as long they did not change the prior use of the water. If they changed the use of their water in any way in the future, they would immediately become a concessionaire to the Government.

Australia's State of Victoria is an example of a government's changing how it allocates water because its goals have changed. Historically, Victoria allocated water to irrigators with the objective of encouraging settlement in rural areas. The water charge to the irrigators was set by the Government. Promoting efficient use of water is now becoming a more important objective. Recently, the additional supplies of water of a newly completed dam were auctioned off by the Victoria Government to the highest bidders.

Policies to Promote Specific Uses of Land and Water

Regardless of the allocative system, countries retain an interest in the uses of their resources. Due to changing conditions or priorities, governments may institute policies to encourage specific uses of their land and water resources.

Land Use Changes

Governments make decisions that lead to conversion from one land use to another. Agricultural area can increase due to policies that

promote the conversion of forest, range, or wetlands. Other policies can change the type of agriculture in a given area. Finally, policies can seek to stem the loss of agricultural area to other uses.

Various types of policies are used, depending upon whether the land is owned by the state. On state-held land, policies can dictate the allowed activities, or the land could be privatized. On privately held land, economic incentives are often used to influence private actions.

Six examples detail policies that lead to changes in the use of land. In the United States, public lands were removed from economic uses in order to create nature reserves. In Brazil, a variety of policies and public investments opened up large areas to colonization, leading to the conversion of natural forest to agriculture. In Spain, agricultural area expanded under policies promoting the drainage of wetlands. In The Netherlands, policies aim to shift the type of agriculture practiced by encouraging large-scale over small-scale agriculture. In Canada, some provinces have policies to slow the conversion of farming lands to urban uses. In the United States, zoning laws restrict the use and transfer of private property.

In the United States, the creation of Yellowstone National Park in 1872 started the movement to reserve public lands in order to protect natural resources and areas of scenic beauty (Sedjo). In 1891, the Forest Reserve Act allowed the set-aside of public lands as public reservations. Two years later, 17 million acres of forest were reserved; by 1908, the total stood at 194.5 million acres. State-owned reserve land could also be increased through the purchase of private land. The Weeks Act of 1911 gave the Forest Service the authority to buy forested and deforested land within watersheds of navigable streams.

Besides the policies described above associated with Brazilian land tenure, the Brazilian Government had other policies that promoted colonization of the Amazon Basin (Barnard). Through a large road-building program, beginning with the Trans-Amazon Highway, the Government sought to open up the Amazon to development. Incentives helped establish large cattle ranching, logging, and mining operations. Tax policies granted a 50-percent credit against Federal income tax liabilities for approved projects, primarily cattle ranching. As mentioned above, agricultural income was almost tax-exempt. Approved agricultural projects also received subsidized credit with negative real rates of interest. Depending upon the intensity of land use, land taxes could be reduced by up to 90 percent. Land could be improved by converting forestland to pasture, which reduces land taxes. All these policies encouraged the conversion of land from forest to agricultural purposes.

In Spain, there have been both public and private efforts to drain wetlands for conversion into farmlands (DocTer). In 1918, a policy provided financial assistance for draining lagoons, swamps, and mudlands. A 1973 law declared that the transformation of swamps and reclaimable land was a major national interest. These policies contributed to the drainage and conversion of large areas of wetlands to agricultural uses. In 1985, however, the Government repealed these policies and replaced them with new legislation that called for prior approval of any activity that might affect wetlands. Wetland drainage can still occur for health or other public interest purposes, if agencies approve.

Besides encouraging changes in land use from natural habitat to agricultural areas, policies also can promote changes from small-scale, inefficient agricultural land to large-scale agricultural plots. The Netherlands has such a policy in their Land Consolidation Act of 1985 (DocTer). If the distribution of land ownership and infrastructure impedes an efficient agricultural structure, and if most of the landowners agree, then land can be reallocated. The public compensates farmers for their losses and finances the required infrastructure, such as new roads and rerouted waterways. The Ministry of Agriculture is in charge of buying and selling land for land consolidation. This program restructures 30,000 to 40,000 hectares per year.

Policies also can attempt to influence the loss of agricultural land to other uses, such as urban growth. In Canada, private efforts converted 300,000 hectares from rural land to urban land from 1966 to 1986 (Simone). Although this is a small percentage of Canada's agricultural base, over half of the area lost was prime agricultural land. During the 1970's, the Provinces of British Columbia and Quebec passed legislation that sought to control the loss of farmland to nonagricultural uses. However, most other provincial governments have not established conversion controls, so agricultural land continues to be developed for urban uses.

In the United States, private owners hold a large part of the land. There are proscriptions on how private land can be used, however (Hamilton). Local governments are the primary creators of restrictions on land use, so these restrictions vary by locality. Land-use controls seek to promote rational development and reduce conflicts over disparate uses of the land. County zoning ordinances classify land into various use categories and detail permitted uses. Often, zoning rules protect farmland from conversion into nonagricultural uses. Agricultural preservation laws exist in some States. These laws seek to preserve farming land by placing severe restrictions on the conversion of land to nonagricultural purposes. Similarly, right-to-farm ordinances seek to preserve not only agricultural land, but also farms. These laws restrict newcomers to agricultural areas in filing grievances or nuisance suits against agricultural operations, claiming, for instance, that nearby farms emit offensive odors. Zoning laws also can restrict agricultural practices, however. In some zones, rules may not permit agricultural practices, or new zoning restrictions may curtail the ability to expand or sustain farming operations. Thus, zoning laws may benefit or harm agricultural interests by placing restrictions on how private property may be used. While zoning ordinances seek to segregate conflicting uses of the land, many land owners claim that they result in the "taking" of rights to use the land and reduce the value of the land.

Water Use Changes

The water allocative system developed by each country is the framework for policymakers to control the use made of water. For example, when a country uses a permit system, its government bureaucracy can allocate water to certain uses and can reallocate it as conditions change. This point is illustrated by the situation in Israel. Other Governments do not exercise such direct control over the use of water, but the public can still attempt to promote or limit certain uses of water through subsidies, taxes, or penalties. The U.S. subsidization of irrigation is an example of promoting a particular use of water.

Israel is an example of a country using its permit system to reallocate the use made of its water. All water resources in Israel are public property and the Government allocates this water to urban, industrial, and agricultural users through a licensing system. Licenses are valid for 1 year and set the quantities of water to be withdrawn and its use. Current Government policy is to shift freshwater away from irrigated agriculture to supply the rising needs of residential and industrial users. The transfer is accomplished by changing the licenses when they are renewed. The Government will increase the supply of treated, urban wastewater to agriculture to substitute for the transferred freshwater.

Many countries have developed subsidized irrigation schemes to promote economic development. The United States, for example, subsidized large-scale, surface-water irrigation projects in the arid and semiarid West to promote the region's economic development. The Federal Government began its involvement in Western water development under its general policy to promote settlement of the West. The Reclamation Act of 1902 created the Bureau of Reclamation and charged it with planning and constructing major irrigation projects in the West. The 1902 Act states that the title and operation of the reservoirs will remain with the Federal Government, while the off-stream irrigation works are the responsibility of the irrigators. The Bureau provides the water to irrigators under long-term contracts at a subsidized price. Revenues from Federal hydroelectric power cover costs beyond the irrigators' ability to pay.

Policies to Conserve Land and Improve Water Quality

Another goal of many governments is sustainable resource management. Depending upon priorities and financial resources, countries may institute policies to conserve or preserve land and to improve water quality.

Land Conservation Policies

The final land-use choice that governments must address is the extent to which they wish to conserve soil quality and quantity. Policies can operate on a national, regional, or local basis. Policies usually target land with specific problems, such as susceptibility to soil erosion, or land that has certain characteristics, such as wildlife habitat or landscape beauty.

Four examples describe policies that seek to conserve or preserve resources. In the United States, the Conservation Reserve Program seeks to retire highly erodible or environmentally sensitive land from farming. In Canada, conservation policies, generally, are initiated at and targeted to

the provincial level. In Germany, programs encourage nature preservation with a system of varying financial incentives. Finally, in Zambia, more targeted policies seek to preserve areas surrounding parks and promote forestry in order to curb soil erosion.

In the United States, the Department of Agriculture's commodity price support programs, begun in the 1930's, affected the use of private cropland. By making farming more profitable, the programs encouraged more land to be brought into production, including marginal land susceptible to erosion. Conversion of range, forest, and wetlands to higher value cropland occurred. By supporting a limited number of crops, commodity production became specialized. The use of sustainable land management practices, such as crop rotation, declined.

The U.S. Conservation Reserve Program (CRP), begun in 1985, addresses the potentially harmful nature of the commodity programs (Osborn, 1992). It offers rental payments for the retirement of cropland to grass or forestland. Under a bidding system, farmers compete for 10- to 15-year contracts. The program provides cost-sharing for the establishment of cover crops. Highly erodible or environmentally sensitive land is the only land eligible. Rental rates are allotted through a bidding system. The program has multiple agricultural and environmental goals, such as supply control, maintenance of water quality, provision of wildlife habitat, farm income support, and reduction of soil erosion. The program had minor modification from 1985 through 1988 in order to target certain acres, to address drought conditions, and to refine the incentives (Reichelderfer). In 1990, legislation modified the Department of Agriculture's operating and bid acceptance rules. The program now considers the costs and benefits of enrollment and requires useful-life easements in some areas (Osborn, 1991). The new legislation also broadened the CRP, by increasing the types of land eligible for enrollment, and tightened it, by more closely targeting the criteria for acreage acceptance. The 1990 legislation calls for the CRP to be expanded to between 39 million to 44 million acres, up from the 34 million acres enrolled by 1990. Rangeland, forestland, wildlife habitat, filter strips, and windbreaks have increased due to the retirement of cropland. Soil erosion has declined, ground and surface water quality has improved, soil productivity has increased, and wildlife populations have grown. USDA estimates of the total direct program costs of the CRP are $14.6 billion, although savings from reduced commodity program payments are approximately $5.3 to $8 billion (Osborn, 1992).

In Canada, provinces have the primary responsibility for natural resource conservation (Simone). Different programs exist across the provinces because the programs target regional conservation issues. In eastern Canada, drainage, soil fertility, and reforestation are the primary concerns, while in western Canada, land rehabilitation, erosion control, drainage, irrigation, and tillage practices are the issues addressed. The Federal Government also has two programs that target soil conservation. In 1935 the Government established the Prairie Farm Rehabilitation Administration, which operates in the Prairie Provinces and the Peace River region of British Columbia. This program provides technical and financial assistance for soil and water conservation and development. Agricultural Development Agreements between the Federal and provincial governments promote regional agricultural development. Besides encouraging agricultural production, the Agreements also foster improved soil and water management practices.

In Germany, a voluntary approach providing financial incentives promotes resource conservation and preservation (DocTer). States offer contractual agreements to farmers for their protection of the perimeters of cultivated land, stream and river banks, wetlands, and arid grasslands. In 1986, for example, average compensation payments ranged from 250 DM/ha/year for acceptance of restrictions on plowing green meadowland, to 3,500 DM/ha/year for the preservation and care of hedges, woods, and thickets.

In Zambia, the Government designed more limited and concentrated conservation policies, as is typical of less developed countries (Mabbs-Zeno). Programs protect the surrounding areas outside of national parks and forests from unsustainable uses and natural resource degradation. The Soil Conservation and Agro-Forestry Program primarily provides training, but also has encouraged the planting of trees for fruit production in homesteads and for pole production in wetlands. This program targets its efforts based on the erosion hazard rate and community interest.

Water Quality Policies

The public also needs to protect the quality of its water supplies. Besides controlling pollutants disposed of directly into water bodies, there is also the need to protect the quality of rainwater as it flows over the land or percolates through the soil. To illustrate how countries can protect their water resources from agricultural pollution, the voluntary and mandatory programs for limiting nitrate pollution from livestock in the United States and two European Community countries are discussed.

Responsibility for protecting the quality of the United States's water is divided between the Federal Government and the States. For livestock farms, generally, the size of the operation determines whether the farm is under Federal or State regulation. All livestock operations greater than 1,000 feeder cattle (or their equivalent in animal units) that discharge wastes by any means into surface water are under Federal regulation and are required to construct facilities for pollution abatement. In addition, operations greater than 300 units that discharge livestock wastes into surface waters, either through constructed conveyances or directly by the livestock, are also under this Federal regulation. Generally, only the States require smaller livestock operations to construct facilities for pollution abatement to protect surface waters. The Federal regulations do not apply to groundwater. There is a voluntary, Federal subsidy program for constructing abatement facilities available to farmers not already required by Federal or State law to construct such facilities.

The European Community (EC) is also dealing with nitrate pollution from livestock farms. In contrast to the technology standard of the United States, where all operations above a specific size must install similar pollution abatement facilities, the EC approach has focused on the quality of the water itself. Initially, the EC legislated the maximum allowable nitrate content of drinking water supplies in member countries. Later, the EC extended its nitrate standard to all water supplies. Each member country is then expected to achieve this water quality standard using methods of its own choosing.

The United Kingdom's response to the initial EC drinking water standard was to rely on water treatment measures, not preventative measures. Where possible, contaminated sources of drinking water were blended with higher quality sources before the water was delivered to the users. Where high quality sources of water were not available, denitrification technology was employed.

Under the current EC legislation that extended the nitrate water quality standard to all water, the United Kingdom has passed national legislation to create Nitrate Sensitive Areas (NSAs) in which farming practices will be regulated according to the Code of Good Agricultural Practice for the Protection of Water. NSAs are areas where water is already polluted by nitrates above the EC standard or vulnerable to nitrate pollution. Only a few areas have been identified as NSAs. Complying with the Code will still be voluntary outside these identified areas.

The United Kingdom does have countrywide regulations for manure storage. Failure to comply with these regulations is an offense. The Government, however, does provide grants to farmers for constructing or improving manure storage facilities.

In The Netherlands, surplus manure is taxed. Surplus manure is that which is produced on a farm in excess of the quantity that can be recycled on that farm's land without risk of nitrates leaching into the groundwater. Farmers are required to pay for the cost of transporting surplus manure elsewhere in the country for land disposal. The Government is constructing facilities to process surplus manure into fertilizer pellets that can be sold elsewhere, usually at a financial loss. This processing is partially financed by the surplus manure tax. There is also a levy on feed manufacturers that helps to cover the cost of this processing. The goal of this processing is not to make a profit, but to ensure the survival of the present livestock sector.

Summary

Land and water are two critical resources with many competing, beneficial uses. Policies to manage land and water have effects on the environment, production, and trade. In order to promote rational development and reduce conflicts, there must be a legal framework for allocating these resources among potential users. The allocative system developed by a country will be the result of many factors, including the history of the country and scarcity of the resource. When the allocative system does not meet public goals, including economic development and environmental protection, policymakers can try to

achieve the public's land and water goals through mandatory controls, economic incentives, or economic disincentives for the individuals or entities using the resources. If these actions are not successful, the country may have to change its legal system to achieve its goals.

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Chapter 5
Multilateral Environmental Activities

Carl Mabbs-Zeno

With increasing global concern over environmental issues has come a series of multilateral agreements, programs, and policies specifically directed at environmental protection. The nature of the multilateral institutions involved in these programs shapes the mechanisms they are willing and able to employ in this effort. Furthermore, many of their programs which are not motivated by environmental concerns have environmental impacts that are increasingly scrutinized. This paper examines how the programs of multilateral institutions are directed toward environmental issues. These programs are categorized into multilateral trade agreements, multilateral environmental agreements, and multilateral environmental grants and loans. Emphasis here is placed on programs that affect trade or agriculture.

Introduction

International interest is drawn toward environmental problems for several reasons, including instances of: (1) unidirectional spillover across national borders, (2) multidirectionally shared resources, (3) competitiveness, (4) creditworthiness, and (5) ethical concerns. Each of these is associated with a characteristic form of response. The nature of the response varies between private and public, or bilateral and multilateral.[1]

Unidirectional spillover across national borders refers to cases of environmental damage affecting at least one country other than the one in which the damage originates. The actions of a particular country, whether environmentally damaging or protective, affect neighboring countries, although the neighbor does not have any direct effect on the first country. For example, pollution into a river affects downstream users of the river, while the downstream user has no effect on the polluter.

In cases of multidirectionally shared resources, the set of countries affecting environmental quality and the set of those where the environment is affected overlap. Such shared resources include the oceans and the atmosphere.

When environmental policies differ among countries in ways that are seen to affect their competitive advantage, the issue of competitiveness emerges. Interests within a country place pressure on policies with apparent environmental purposes to account for trade interests. The key determination guiding acceptability of environmental policies with trade effects is how well the environmental purpose is served by the policy relative to the trade effect.

Environmental effects are of concern to lenders, regardless of whether they or the borrowers are public or private, if environmental constraints affect ability to repay a loan. Loans whose repayment is dependent on agricultural production, for example, are riskier where environmental damage can severely reduce production.

A range of concerns over environmental problems in other countries originates in ethical positions. For example, people may believe that some animals, living in foreign lands, inherently deserve protection. The existence of this wildlife may offer conventional spillover benefits, such as the genetic reserve they supply, but much of the interest by foreign citizens in their existence cannot be attributed to any concrete good or service derived from the animals. Ethical appeals are most effective among people with similar cultural background and, thus, shared philosophical histories. Ethical appeals are unlikely to drive the activity of multilateral international organizations composed of diverse cultural elements, but they are significant in a few cases.

At the broadest level of categorization, the forms of international response are separable into those in which each nation has the same fundamental role and those in which nations are identified as donors or recipients. Nations acting as equals

[1]Purely unilateral programs affecting international environmental issues are typically motivated by domestic concerns, despite their broader impact. Efforts that reduce pollution to domestic river users might benefit users of countries downstream. Research programs that improve efficiency of resource use similarly might benefit other countries.

conclude agreements in which the signatories all bear responsibilities and receive benefits.[2] This contrasts, in theory, with relationships based on grants or concessionary loans, but, in practice, grants and loans are often conditional on terms that benefit the apparent donor.[3] Even so, nearly all agreements between or among nations could be clearly assigned to one of these two categories of either "same fundamental role" or "donors or recipients."

Multilateral Trade Agreements

Agreements whose main purposes are related to trade often have environmental implications, but, until recently, rarely treated those implications explicitly. Since 1990, various environmental considerations played substantive roles during the negotiations on the North American Free Trade Agreement (NAFTA) and the renegotiation of the General Agreement on Tariffs and Trade (GATT). The U.N. Conference on Trade and Development (UNCTAD) has increased its emphasis on sustainability as a component of development. Sustainability of economic performance results from interaction among all components of the economy, and many of the best recognized challenges to sustainability require protection of natural resources.

The NAFTA is principally oriented toward lowering trade barriers among its signatories, but it is accompanied by a side agreement on environmental protection. These provisions specify that signatories should adjust their environmental regulations to the highest standard prevailing among them. This represents an attempt to prevent Mexico, mainly, from benefiting from lower standards than the Canada and the United States. Much of the adjustment in Mexico is likely to occur along the U.S.-Mexican border under a pact for alleviating pollution problems between 1992 and 1994. It was originally funded with $400 million from the Mexican Government and $341 million from the U.S. Government.

The purposes of the GATT are myriad but do not expressly include environmental protection (GATT 1991b). In the GATT report to the U.N. Conference on Environment and Development (UNCED) and in other recent GATT releases, the benefits of free trade were described as an implicit defense of the GATT efforts to reduce trade barriers (GATT 1992). The report shows that rich countries pollute less than countries of intermediate income, and that trade has considerable capacity to spread improved technology, including technology more environmentally benign than typically used.

Countries fear that the burden of environmental laws will put them at a competitive disadvantage in trade. Although many GATT members accept that harmonization of environmental standards is a legitimate trade procedure, such harmonization is not an integral part of the current agreement on GATT (GATT 1991b). Tariff barriers to offset environmental programs are not accepted within the intent of the GATT. For example, Article XX of the GATT states "...nothing in this Agreement shall be construed to prevent the adoption or enforcement by any contracting party of measures ... (b)necessary to protect human, animal or plant life or health ...(g)relating to the conservation of exhaustible resources if such measures are made effective in conjunction with restrictions on domestic production or consumption." This stipulation is subject to two conditions: that such measures "not be applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail" and that they not be "a disguised restriction on international trade."

Thus, environmental policies are generally consistent with the GATT but several disputes have arisen over the interpretation of what is environmentally justified. In a case discussed by Skully in this volume, the United States was challenged for its embargo on Mexican tuna, which had been instituted to protect dolphins from the methods employed by Mexican tuna fishermen. The panel of GATT judges decided that national policies may not be used to protect the environment beyond its national borders (Mathews 1991). This finding calls into question potential GATT acceptance of many environmental actions with international consequences. In discussions during May 1991, the Nordic countries specifically stressed "the GATT principle of 'national treatment' did not mean that countries were free under Article XX to require that imported products are produced as cleanly abroad as at home" (GATT 1991b, p.3).

[2]As used here, treaties include organizations developed to administer a specific international agreement.

[3]This practice is more pronounced in bilateral agreements than in multilateral ones.

During the Uruguay Round of negotiations, which started in 1986 and just concluded, environmental issues gained increasing attention without being directly negotiated. They are being considered now through the GATT's Group on Environmental Measures, which was established in 1971 but never convened until 1992 (GATT 1991a). GATT has already accepted trade restrictions on substances that are considered hazardous enough by an exporter to restrict domestically. These restrictions are investigated in the Working Group on Export of Domestically Prohibited Goods and Other Hazardous Substances, which was formed in 1989.

The eighth UNCTAD conference, held in February 1992, placed sustainable development among the priority areas of UNCTAD's mandate.[4] It followed similar directions from the Trade and Development Board, affirmed by the U.N. General Assembly in December 1990. The most concrete form of response from UNCTAD to this priority has been on the assignment "to collect, analyse, and disseminate information on environmental regulations and measures which may have an impact on trade, especially that of developing countries" (UNCTAD 1992a, para. 155). This response was further motivated by the U.N. Conference on Environment and Development (UNCED), held in June 1992. UNCED specifically called for UNCTAD and GATT to contribute to the implementation of Agenda 21 through research and dialogue on the relationship between trade, development, and the environment (UNCED 1992, Sec. 1, Chap. 1).[5]

UNCTAD's data development program is termed "Green Trade" or "Green and Development" (GRADE). It adjusts UNCTAD's existing Trade Control Measures Data Base to include environmental regulations and measures by linking an additional database to the present system. The new database will utilize information from questionnaires sent to member countries regarding their adoption of various policies, such as emission taxes, administrative charges on environmental programs, tradable permits, emission standards, and trade restrictions motivated by environmental concerns. Two series of studies are envisioned, one defined thematically and one based on individual country situations. These will explore both the effect of environment on trade and the effect of trade on the environment (UNCTAD 1992b).

Multilateral Environmental Agreements

Agreements whose purposes substantively include environmental protection are typically efforts to manage shared resources. Trade measures are occasionally among the controls used by such agreements.[6] Global agreements have been concluded to manage marine fishing, whaling, pollution and mining, air pollution, and the resources of Antarctica.[7]

Rights to marine resources were clarified by the Law of the Sea in 1982. Numerous agreements exist for the protection of individual bodies of water. The Convention on Fishing and Conservation of Living Resources of the High Seas, which entered into force in 1966, establishes marine fish conservation measures globally and includes provision for enforcement through the U.N. Whaling Commission. This Convention is controlled through relatively stringent regulations under the International Convention for the Regulation of Whaling, which has been in force in various forms since 1948. In recent years, the terms of this agreement extended to assigning national quotas on annual catches.

Marine pollution is managed by the International Maritime Organization, established by the U.N. Maritime Conference of 1948. Controls are placed on petroleum spills, hazardous waste and land-based release of waste or heated water. Separate agreements are in force for various regions and for various types of pollution. Generally, these agreements prohibit dumping that is hazardous to human health, providing mechanisms for dispute settlement, enforcement, and compensation for damages.

International air pollution agreements generally deal with either reducing acid raid or protecting the ozone layer of the atmosphere. In 1983 the Convention on Long-Range Transboundary Air Pollution took effect. It establishes that countries do not have the right to engage in activities that result in acid rain falling on their neighbors. While

[4]The Cartegena Commitment, which was the product of that meeting, states the international community should "ensure that environment and trade policies are mutually supportive with a view to achieving sustainable development" (UNCTAD 1992a, para. 126).

[5]Agenda 21 is the action plan passed by UNCED.

[6]The GATT Secretariat lists 17 multilateral environmental agreements with trade provisions currently in force (GATT 1992).

[7]Most international controls on air pollution treat all nations similarly to protect the shared atmosphere.

not binding on signatories, it was followed by numerous, binding bilateral agreements. Ozone protection efforts in the early 1970's were concerned with the effects of pollution by aircraft and spacecraft, and by nitrous oxide released from fertilizer. These concerns were not supported by sufficient scientific evidence to lead to international policy reform, but, in the mid-1970's, the threat to ozone from chloroflourocarbons was established. More recently, the threat to the ozone from the use of methyl bromide fumigants was recognized, as discussed by Forsythe and Evangelou in chapter 10.[8] The U.N. Environment Programme (UNEP) led several efforts to control chloroflourocarbon use, culminating in the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987. Various prohibitions on trade in these chemicals form the central implementation mechanism of the agreement. Pollution from nuclear weapons testing has been subject to controls since 1963 in the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water.

Spillover

Agreements to control unidirectional spillover effects are typically arranged between two or a few neighboring countries. Most common are the agreements that allocate rights to water use within a watershed. About 300 treaties have been signed to manage the 200 rivers that course through more than one country (Rogers 1991). Air and water pollution flowing in a consistent direction across specific international borders might also be the subject of agreements that tend to proscribe the activities of one or a set of countries to protect another set of countries.[9] International efforts to protect endangered species are largely based on the spillover effects of reduced genetic diversity, although some ethical arguments also apply.

Over 20,000 species of plants and 500 species of animals are protected by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). It has been signed by well over 100 countries and has been in force since 1975. It utilizes trade controls, including some bans on trade, to protect specified wildlife species that are already endangered or may become endangered without trade control. Wetlands that provide habitat for migratory birds are protected through the 1975 Convention on Wetlands of International Importance, also known as the Ramsar Convention. The 1985 International Tropical Timber Agreement does not expressly control trade in wood, but it monitors such trade and provides a forum for research and discussion through the International Tropical Timber Organization.

The transmission of plant pests and diseases through trade has been limited by the International Plant Protection Convention since 1951. This agreement has been administered by the Food and Agriculture Organization of the United Nations (FAO). A similar treaty has been in effect since 1960 among countries formerly allied with the Soviet Union, the Agreement Concerning Co-operation in the Quarantine of Plants and their Protection against Pests and Diseases. A more active program of cooperation has been developed for control of desert locusts through various regional commissions following the 1962 Convention on the African Migratory Locust.

Ethics

Ethical concerns probably form the central rationale behind agreements protecting national heritage (including cultural, historical and natural sites and objects), protecting farm animals, and controlling hazardous waste. The principal multilateral agreement covering the first of these areas is the Convention for the Protection of the World Cultural and National Heritage, which entered into force in 1975 and functions, in part, through the United Nations Educational, Scientific, and Cultural Organization (UNESCO). It relies partly on trade barriers to reduce exports of historically significant material from the country of origin. The 1978 European Convention for the Protection of Animals Kept for Farming Purposes sets general standards for treatment of animals in intensive agricultural systems, although it provides no enforcement measures.

The cases of dumping hazardous waste involve unconventional trade issues because they constitute trade in "bads," with a negative price, rather than in "goods."[10] Dumping of waste in a country other than the country of origin has occurred in several cases where the recipient was poorly informed of risks or where government officials were not informed at all. Such "unethical"

[8]Five to 10 percent of ozone depletion is attributed to methyl bromide use (Kenworthy 1993).

[9]Most controls on freshwater treat nations according to their location in the water system rather than as equals.

[10]A few cases have involved agricultural considerations, like the transfer of 10,000 barrels of waste to Koko, Nigeria from Italy in 1987-88. The waste was dumped in agricultural fields without the knowledge of the farmers (Lean and coauthors 1990, p. 101).

trade is likely between relatively rich and relatively poor countries due to the large difference in cost of handling waste.[11] In 1989, about 2 million tons of hazardous waste were exported from West to East Europe (Lean and coauthors 1990). Trade among relatively rich countries, however, is more common, with Britain the largest importer of hazardous waste, earning $1.2 billion in 1987 for processing waste of foreign origin (Economist 1988).

The major agreement on trade in hazardous waste is termed the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. It was negotiated in 1989 following a UNEP initiative, but did not enter into force until May 1992 (Greenpeace Waste Trade Update 1992).[12] It defines hazardous waste broadly, establishes procedures for consent prior to shipment, and provides that the exporter must accept re-import of the waste if the initial importer cannot dispose of the waste in an environmentally sound manner. The European Community and the Organization for Economic Cooperation and Development also have agreements on such trade.

Constraints on effectiveness

Multilateral environmental agreements are appropriate tools when international action is motivated by economic costs being imposed on neighboring countries, such as occurs with spillover effects or shared resources. They are less appropriate as tools for achieving creditworthiness in poor countries or for assuring competitiveness among countries.

Even when motivated by appropriate issues, agreements are inherently limited as an approach to resource management. They are difficult to enforce when they conflict with domestic priorities of signatories and when the signatories face different incentives for compliance.[13] In these circumstances, relatively effective, alternative, international approaches are often available.

Most environmental damage results from activities that have little international effect and that are unresponsive to available international pressures. For example, poaching of wildlife for local meat consumption or clearing of rainforest for agriculture are probably little affected by an international agreement like CITES. A few issues are effectively addressed at this level, like those affecting the ozone layer, where the form of damage at issue can be monitored, widespread agreement among countries is forthcoming, and countries share relatively evenly in the effects of action. Effective use of multilateral agreements requires that they be limited to appropriate cases so they do not distract public effort from domestic programs (Robertson 1990). Enforcement of agreements among sovereign nations is hampered by the nearly inevitable difference in net value of compliance for each country. Each agreement has signatories for which noncompliance would cause little harm at home.

The problems that agreements cannot alleviate can be solved, in part, by international environmental loans or grants. Enforcement can also be strengthened by addressing environmental issues in multilateral organizations so broad that no member can ignore any provision without fear of suffering costs through some other provision. Environmental purposes have become increasingly important in trade organizations, for example.

Multilateral Environmental Grants and Loans

The environmental components of multilateral agreements discussed above are motivated by effects of countries on the environments of other countries. It is often also in the interests, however, of a particular country that the environment within another country be protected. For example, importing countries benefit from price stability made possible by sustainable production practices in exporting countries. Exporting countries benefit from economic development in importing countries and are hurt if it is not sustainable in the importing countries. Developing countries, in particular, rely on agriculture and exploitation of natural resources to pay for imports.

Controlling environmental problems in developing countries will require investment and expertise that is unlikely to come from within those own

[11] In 1989, the cost of dumping a ton of hazardous waste in the United States was as high as $2,500 and was estimated by other analysts as between $75 and $1,500 in Western Europe (Shabocoff 1989). Costs in developing countries ranged from $2.50 to $40 a ton (Montgomery 1990).

[12] The United States has not ratified the Basel Convention. It has agreements on transboundary shipment of waste with Canada and Mexico. Most U.S. waste exports go to Canada (85 percent in 1987) (USITC 1991, p. 5-65).

[13] Of course, numerous other problems constrain the effectiveness of international treaties, like the uneven power of potential signatories to negotiate, delay during negotiations, monitoring costs, and eventual need to update and renegotiate (French 1992).

Table 1--Increased environmental investment needed in developing countries

Program	Cost
	Billion dollars per year
Water provision and sanitation	10.0
Reducing particulate emissions from coal-fired power stations	2.0
Reducing acid deposition from new coal-fired power stations	5.0
Controlling pollutants from vehicles	10.0
Reducing industrial wastes	10.0-15.0
Soil conservation and afforestation	15.0-20.0
Agricultural and forestry research	5.0
Family planning	7.0
Education for girls	2.5

Source: World Bank 1992b, p. 174.

economies. The need for investment in several environmental areas was estimated by the World Bank to total over $70 billion per year, about 1.4percent of their combined gross domestic product (table 1). Foreign donors and lenders may fill part of the gap. One of the main topics of debate at the U.N. Conference on Environment and Development (UNCED) meeting in 1992 was how much investment in environmental protection in developing countries would come from developed nations but no final commitment was made. The plans emerging from UNCED call for $600 billion, including $125 billion from developed countries.

The United Nations system includes several components with substantial environmental programs. These were brought together in mid-1992 by the U.N. Conference on Environment and Development. Prior to UNCED, the broadest based component was probably the Global Environmental Facility, which is jointly administered by UNEP, the U.N. Development Programme (UNDP) and the World Bank. The Food and Agriculture Organization, UNESCO, and UNCTAD are also active in this area.

The United Nations Conference on Environment and Development met in Rio de Janeiro to advance the international commitment to environmental protection that was first expressed within the U.N. by the Stockholm Declaration on the Human Environment in 1972 and then by the Nairobi Declaration in 1982. At the Rio meeting, developing nations sought long-term support from donor nations in return for their support of environmental goals.

UNCED produced two major products, the Rio Declaration on Environment and Development, and a nonbinding action plan termed "Agenda 21," a reference to the 21st Century. The Rio Declaration contains principles of sustainable development, while Agenda 21 includes a plan for international aid for poverty alleviation and environmental health, research, family planning, and education, especially for girls (see table 1). It also discusses reducing policies that have a damaging impact on the environment, financing wildlife habitat, and promoting open trade. Other initiatives from UNCED included the Climate Change Convention and the Convention on Biodiversity, each signed by over 150 countries. "Principles for a Global Consensus on Forests" was written and an intergovernmental committee was planned to negotiate a convention on desertification. The results of UNCED will be coordinated by the new Sustainable Development Commission within the U.N. Economic and Social Council.

The Global Environmental Facility and its companion, the Multilateral Fund (or Ozone Fund), were established in 1990 to reduce global warming by improving efficiency of energy use, reducing emissions from energy production, reducing emissions of "greenhouse" gases other than carbon dioxide, and slowing deforestation (World Bank 1992b, p. 176). The World Bank administers the Global Environmental Facility with disbursements of $1.3 billion in its first 3 years. By the end of 1992, the Facility was considering over 70 projects costing $580 million and had approved 60 projects costing $80 million. The distribution of lending to date strongly reflects the targets of 40-50 percent to reduce global warming, 30-40 percent to preserve biological diversity, and 10-20 percent to protect international waters (World Bank 1992a). UNEP assists the Facility by assuring that its policies are consistent with existing international legal strictures. UNDP assists with preinvestment studies, training for local officials, and coordination among donors at the country level. The Multilateral Fund of $160 million is administered by UNDP through the Montreal Protocol, although the two funds will

eventually be merged ("Global Environmental Facility," 1991).

UNDP is the main funding organization for technical assistance within the United Nations system. It supports over 5,000 projects whose combined cost exceeds $8 billion, including about $1 billion annually. These numbers place UNDP well below the World Bank and the regional development banks in expenditure levels, but UNDP is unique with its breadth of representation across the developing world (112 countries), its abstention from projects funding physical infrastructure, and its reliance on development criteria to evaluate projects.

UNEP was created in 1972, 2 years after UNDP, just as environmental issues were becoming recognized internationally. Responsibilities were allocated between these two organizations under the assumption that UNDP would coordinate work within the U.N. development agencies while UNEP would act as a catalyst for environmental action within the U.N. system. However, within 10 years, UNDP had suffered through two financial crises, leaving the U.N. development agencies largely independent and leaving UNEP with no financial resources to fulfill its mandate (von Moltke 1992).

Despite these difficulties, UNEP has numerous significant accomplishments. It organized many of the most important international agreements protecting the environment, including: conventions protecting endangered species, the migratory species, and the ozone layer, and requiring the safe disposal of hazardous waste. UNEP also organizes and maintains numerous databases that monitor the global environment, and conducts research assessing environmental problems.

In late 1989, the World Bank adopted a plan for 3 years to strengthen its efforts for environmental protection. Five problems were identified as priorities:

(1) destruction of natural habitat,
(2) land degradation,
(3) degradation and depletion of freshwater resources,
(4) urban, industrial and agricultural pollution, and
(5) degradation of the "global commons."

The World Bank approved 117 projects in fiscal 1990 that had environmental objectives. About half of all loans had environmental components in that year, the first in which environmental lending was fully reported (World Bank 1990). In fiscal 1992, 19 specifically environmental projects were funded for a total amount of $1.2 billion in lending. Another 43 projects had significant environmental components (World Bank 1992a).

Environmental issues papers for internal Bank use were prepared for all member countries. They are being followed by National Environmental Action Plans being prepared with Bank support by each borrowing country. These plans are prepared by special task forces within national governments and recommend actions to improve the following:

(1) environmental policy and legislation,
(2) the institutional framework for dealing with the environment,
(3) national capacity for environmental assessment,
(4) environmental information systems,
(5) assessment of costs from environmental degradation, and
(6) education and training (Falloux and coauthors, 1991).

Several organizations are cooperating in a series of planning efforts called Tropical Forest Action Plans, directed at better use of natural resources in forested areas. The principal organization in this program is the FAO with support from UNDP, the World Bank, and the World Resources Institute. This program assists local planning of resource use with training materials and field coordinators who emphasize local management. The technical support highlights linkages between local activities and the rest of the economy (FAO, 1991).

Among the regional development banks, the Inter-American Development Bank is noteworthy for its environmental emphasis. The Bank has adopted five lines of action to promote environmental protection while accomplishing other development goals, including:

(1) providing essential services while avoiding air pollution, especially in urban areas,
(2) rehabilitating ecosystems through soil and water conservation and appropriate agricultural and agro-forestry practices,
(3) promoting sustainable use of forests and fisheries while channeling their benefits to local communities,
(4) conserving the region's natural heritage, especially tropical rainforest, and

(5) conserving natural and cultural heritage of indigenous peoples.

Beginning in 1990, all operations have been classified according to their environmental impact. Of 225 operations reviewed in 1990, 186 were classified in the two most environmentally friendly categories (out of five categories). Five were classified as having significantly negative environmental impact (Inter-American Development Bank, 1991).

The International Monetary Fund does little to target environmental protection in its lending. In 1991 it announced a policy of recognizing the linkage between its recommended policies and the environment, avoiding negative consequences, and promoting sustainable growth. It now coordinates with more active environmental institutions and exchanges information relevant to environmentally sensitive policy formation (IMF, 1992).

Nongovernmental organizations, some of which are international in membership, also play a role in providing technical assistance and project funds and in mobilizing local organizations. The efforts of the largest of these, including the International Union for Conservation of Nature and Natural Resources (IUCN), the World Wide Fund for Nature and the World Resources Institute, are typically coordinated with activities of local governments, the World Bank, and UNDP. The largest of these is the World Wildlife Fund for Nature, which originated as a funding organization of IUCN in 1961, but has since become independent. It has over 4 million members and 23 affiliated national organizations which have, together, funded over 3,000 projects.

The nongovernmental organizations have led the approach to conservation known as "debt for nature swaps." The first agreement that exchanged international debt obligations for commitments to protect nature was principally between Conservation International and the Bolivian Government in 1987 (Page 1989). Despite delay in compliance with the terms of this agreement, similar arrangements have followed. By 1992, 18 more "swaps" were made, retiring $61 million of debt. Most of these were in Latin America, with five in Africa and one each in Europe and Asia (Mahony 1992). The procedure was also extended for purposes of promoting development other than environmental concerns. Commercial banks have supported the exchange of risky debt held by developing countries and have at times been the principal financial beneficiaries of the exchanges. The development banks have shown interest in participating, including the Asian and African Development Banks, but only the Inter-American Development Bank has taken concrete action to date. It is negotiating $100 million of debt relief to fund tree planting in Mexico (GAO, 1991). The U.S. Agency for International Development has also participated by restructuring debt under PL 480. The U.S. Enterprise for the Americas initiative offers to reduce the level of debt from PL 480, to allow payment of interest in local currency, and to allocate interest payments to natural resource conservation.

Although the debt exchanges continue, there is considerable skepticism regarding their effectiveness (Mahony, 1992). The debt exchanged for environmental or developmental purposes totalled only 0.05 percent external debt globally, so it has not demonstrated a capacity to relieve the debt burden. Such exchanges also contribute to inflation, while subsidizing local, private organizations that may not always be targeted beneficiaries (GAO, 1991).

Conclusions

Clearly, a rich array of approaches to alleviate international environmental problems have been developed in recent years. Environmental problems are widely recognized and policies have been initiated by numerous institutions. The relative effectiveness of these approaches, however, is difficult to assess since the global experience has combined all these approaches, leaving no point of comparison. Many of the policy innovations that confront international environmental problems are too recent to evaluate empirically even where their effects can be isolated.

A superficially safe strategy would be to pursue all approaches simultaneously, but this fails to account for the constraints on time, money, and political effort that bound the overall effort. Creative, analytical mechanisms for determining the relative efficacy of various strategies are needed to focus policies efficiently. Present analysis is inadequate to demonstrate compelling arguments for any particular strategy, although some components of such a strategy can be identified, such as involving private and

governmental, national and multilateral, profit and nonprofit institutions. The experience of the past decade has been one of expending the techniques responding to these problems. The remaining task is to choose among these strategies and to refine their methods in order to confidently treat thepressures that continue to mount on the global resource base.

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Chapter 6
Environmental Standards and Regulations in a Global Context

David Skully

Following up on the discussion of multilateral institutions in the last chapter, this paper emphasizes the role that international organizations may have in resolving disputes over product and process standards. The international institutions which attempt to mediate, regulate, and standardize environmental and health standards are identified and surveyed as to how they resolve these issues.

Introduction

As the Uruguay Round of GATT negotiations drew to a close, trade analysts started to voice their concern about unresolved issues. The interdependence of trade and the environment is one such issue. The challenge facing the international community is to devise some means of distinguishing legitimate environmental and health standards from disguised protectionist trade restrictions. At present, there is no single international institution which monitors and adjudicates environmental and trade issues.

Environmental issues are not formally covered by the GATT, but there is a network of allied treaties and international institutions which regulate and standardize environmental and health standards and attempt to mediate trade disputes that emerge. These institutions will be under increased pressure as more environmental legislation is passed.

The following section provides an overview of the kinds of conflicts which can arise when trade and the environment intersect. The balance of the paper discusses where and how these conflicts are resolved or are not resolved. In particular, I focus on the role of international organizations in resolving disputes over product and process standards. In a final section the harmonization of standards in preferential trade agreements is covered.

Conflicts between Environment and Trade Policies

There are two aspects to the interdependence of trade and environment: environmental policies that affect trade and trade policies that affect the environment. Figure 1 lays out the linkages between policies and their effects. Starting in the upper left-hand corner, trade policies obviously affect the trade of the home country and of its trading partner. The GATT exists to resolve disputes over traditional trade policies, such as tariffs and quantitative restrictions.

The lower left-hand corner of figure 1 covers trade conflicts that may emerge over domestic environmental policies that have international trade consequences. For example, raising domestic pollution standards may also raise production costs of a domestic industry and result in a loss of market share to lower cost imported goods from countries with lower pollution standards. Such a loss of market share may give rise to domestic demands for protection or antidumping actions to insure "fair trade." Similarly, if the government of one country appropriates public funds (or offers tax incentives) to improve the environment, this action may have the indirect effect of lowering the cost of meeting pollution standards of exporting firms. If these firms gain market share in an export market they may be accused of receiving a government subsidy and be subject to antidumping actions.

In the lower right-hand corner, domestic environmental policies presumably have some influence on the domestic environment. However, except for upwind and upstream pollution controls and bans on the export of potentially environmentally unfriendly substances, there are few means for unilateral domestic environmental policies to influence environmental quality beyond domestic borders. The only means by which one sovereign state can influence the environment of another sovereign state is through bilateral or multilateral agreements.

There are many international agreements and accords on the environment which attempt, cooperatively, to achieve environmental goals. The Fur Seal Treaty of 1911 is an early example of international cooperation on the prohibition of certain methods of hunting and capture. International agreements to regulate whaling also

Figure 1

Linkages between policy and effects

	Trade effects	Environmental effects
My trade policy	Your trade My trade GATT resolve trade disputes	Your environment My environment Not yet resolved
My environmental policy	Your trade My trade Standards Code CODEX	Your environment My environment International environmental agreements

have a long history, but it has been difficult to gain universal acceptance of these restrictions. The United Nations Conference on the Human Environment in Stockholm in June 1972 resulted in the Declaration on the Human Environment. This is generally viewed as the first broadly based international accord on the environment. On the 10th anniversary of the Stockholm conference, a UNEP (United Nations Environment Programme) conference in Nairobi resulted in the 1982 World Charter for Nature. Last year, the United Nations Conference on Environment and Development, commonly known as the "Earth Summit," was held in Rio de Janeiro. The summit strengthened many earlier agreements and resulted in a Convention on Biodiversity. There are a plethora of other agreements and manifestos, such as the Convention on International Trade in Endangered Species, and the Montreal Protocol on Substances that Deplete the Ozone Layer.

A weakness in all international agreements is enforcement. There is no supersovereign entity that can dictate how sovereign countries manage their environments. Enforcement of global environmental standards occurs, if it occurs, through world opinion, boycotts, threats of the withdrawal of foreign aid, credit, or the promise of more aid or credit, and trade sanctions.

We have discussed the limited ability of one country to unilaterally improve the environment of another country by means of environmental policies. It is also possible for environmental policies of one country to harm the environment of another country. Strict environmental regulations in richer industrialized countries may result in the export of "dirty" industries to industrializing countries with lower environmental standards. Domestic industries are concerned about this migration for traditional trade reasons: the loss of domestic employment and the threat of low-cost competition from abroad. Individuals and interest groups wishing to safeguard the global environment, not merely the domestic environment, may try to prevent the propagation of "dirty" technologies beyond domestic borders.[1] This is a form of "extraterritoriality," one sovereign country imposing its policy preferences on another, and trade policy is one means to this end. This leads to the last block of figure 1.

[1]The empirical evidence on this migration, one should note, is mixed. (Birdsall and Wheeler, 1991, Low and Yeats, 1991).

The upper right-hand corner of figure 1 covers the environmental effects of trade policies. Trade policies generally have only unintentional environmental effects. For example, many industrialized countries have zero or low tariffs on tropical logs, but for tropical cut lumber and finished tropical wood products, tariff rates are much higher, often prohibitive. These high tariffs exist to protect domestic wood processing industries. The indirect consequence of this protection is to discourage developing countries from adding value to tropical logs by milling and processing. With their export alternatives restricted, developing countries are indirectly encouraged to harvest tropical forests more rapidly. The compound effect of protection on labor-intensive production and other value added to raw materials is to intensify the exploitation of natural resources to earn foreign exchange. If a country has a large debt burden, the incentive to overharvest is even greater.

With the emergence of broad-based political support for action on the global environment, one now witnesses trade policies which are specifically designed to force changes in the trading partner's environment. For example, several countries have passed laws banning the import of animal products harvested in ways they do not approve; other countries have banned the import of ivory and some tropical hardwoods to safeguard, respectively, endangered species and tropical rainforests. Such environmentally based trade restrictions have been challenged by exporting countries. These new environmentally based trade policies are creating difficulties for the global trading system. It is not clear which international body has the authority to adjudicate such disputes, nor is there any substantive means with which to enforce a decision. Moreover, in international law, there is no international constitution or civil code, nor an international supreme court to resolve contradictions among laws and treaties. Since its inception in 1947, the GATT has been concerned with advancing a more liberal world trade order by restricting the kind and degree of trade restrictions countries can enact. Coeval with the GATT has been a series of international environmental treaties and accords which endeavor to improve or protect and preserve the global environment. The Declaration on the Human Environment and the Montreal Protocol on Substances that Deplete the Ozone Layer, for example, each set forth principles advocating environmentally targeted trade restrictions which are clearly at variance with the principles of the GATT.

Using trade restrictions to achieve environmental ends can pit environmental or health and safety groups in one country against more traditional industrial groups in another. Industrial representatives are accustomed to resolving a conflict by bargaining toward the middle. Environmental and health representatives, on the other hand, often approach issues from an ethical "all or nothing" position. The contrasting values and styles of the two groups can lead to unusually difficult negotiations, if not irresolvable, conflicts.[2]

Conflict Resolution

The GATT is the principal forum for the resolution of international trade conflicts. Pure trade disputes are well covered by the GATT and there are excellent texts which address this topic.[3] Most conflicts over environmental policies which have trade effects fall under the rubric of product standards, process and production method standards, and embargoes or bans (See figure 1). This section discusses how disputes under these headings are resolved.

The GATT Agreement on Technical Barriers to Trade

The GATT, during the Tokyo Round (1973-79), initiated a Standards Code, formally known as the Agreement on Technical Barriers to Trade. The Standards Code, as part of the GATT, has no supersovereign authority or enforcement capacity and must rely on the goodwill of member countries to work towards liberal trade. The Standards Code requires that signatory countries provide clear and timely notification of new standards, and that standards be written in universally recognized terms. The visibility or transparency of regulations inhibits the imposition of arbitrary or discriminatory standards. The Standards Code also established a Committee on Technical Barriers to Trade to provide a forum for resolving disputes. Various technical subcommittees exist which attempt to facilitate the bilateral resolution of disputes on technical grounds. If bilateral negotiations fail, disputes are ultimately taken to the Committee for arbitration. If the offending party does not adjust the standard found at variance, the Committee's

[2]The Brundtland Report (1987), commissioned by the World Commission on Environment and Development, advocates approaching the goal of sustainable development by considering a judicious mix of economic and environmental concerns. On the negotiation process, see Gorczynski (1991), Neale and Bazerman (1991).

[3]Jackson (1989b) is an excellent source.

capacity for enforcing its ruling is limited to allowing the offended party to invoke sanctions or retaliatory trade measures. If an offended party does not accept the ruling of the Committee, there is little to prevent it from imposing bilateral sanctions.[4]

A fundamental principle of the Standards Code is "national treatment." Simply stated, this means imported products must be accorded the same inspection standards as similar domestic products. National treatment greatly reduces, but does not eliminate, the risk that a regulatory standard can be used as a nontariff barrier.

An important gap in the Standards Code is that it only covers product standards and does not cover process standards. Product standards regulate the characteristics of the final product, for example, the maximum allowable alcohol content of table wine, or maximum parts per million of strontium 90 in sparkling mineral water. Process and production method (PPM) standards govern how a product is produced or processed. Disputes have emerged because some countries employ product standards while other countries employ process standards. Short of one party adopting the standard of the other, resolution requires mutual recognition of the standards of the disputing parties. This is not particularly easy to negotiate, but in many cases equivalence can be made between a product standard and a process standard. For example, it may be possible for trading partners to agree that a process standard for deboning beef results in a beef product that meets a product standard specifying a maximum amount and size of bone fragments per unit of beef.

At present, process standards are beyond the reach of the Code. There has been considerable discussion about broadening the scope of the Standards Code as part of the Uruguay Round, but we shall not know the final form of the amendment until the recently concluded Round is analyzed. Among the topics under consideration were establishing a defensible scientific basis for standards and processes. The models for this are Codex Alimentarius (see below) which, since 1962, has governed food safety standards, the International Plant Protection Convention, established in 1953, and the International Office of Epizootics, established in 1924.

[4]On the Standards Code and other issues in this section see: Bredahl and Forsythe (1989), Dick (1989), Jackson (1989a), Patterson (1990), and Sexton (1991).

Codex Alimentarius

The Codex Alimentarius Commission is the primary international institution for the regulation of standards for food and agricultural products. It was founded in 1962 by a joint commission of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), both United Nations organizations. Increased regulation and enforcement of domestic food industries in the 1950's frequently affected patterns of international trade and led to trade disputes. Codex was founded to provide a forum where such disputes could be resolved and future disputes prevented. Codex's objectives are to (1) protect the health and interests of consumers and (2) facilitate international trade.

The fundamental principle of Codex, like that of the Standards Code, is "national treatment." Codex has also favored the harmonization of minimum standards among member countries. Global harmonization would result in a universal standard, and would be conducive to international trade as it would eliminate the need to customize products for specific markets with different standards. However, global standards may not be desirable because climatic, ecological, social, and economic differences among countries result in differences in the incidence of pests and diseases and the methods used to control them. Codex has therefore sought unanimity on minimum standards, which allows signatories with greater risk exposure to adopt higher standards.

Codex allows member importers to accept its suggested standards at three levels: (1) to fully accept the standard, (2) to fully accept by a specified target date, and (3) to accept the standard with specified deviations. Codex has four types of standards: commodity standards, maximum levels for food additives, maximum levels of pesticides residues, and process codes, most of which concern sanitation standards in the slaughter of animals and the processing of animal products.

Codex allows for a relatively lengthy negotiation period for the setting of standards. Discussions are generally limited to the scientific evidence on the merits and hazards of different standards; consequently, discussions tend to lack the acrimony of other trade negotiations. The allowance of acceptance with specified deviations (above) must be justified on scientific grounds. Science, however, is rarely black and white.

Disputes can emerge over the a member country's approval or lack of approval of a specific drug or pesticide; countries have different regulatory processes and different data sets which require different testing standards. The interpretation of scientific test data is not straightforward and reflects different risk preferences.

Although Codex is primarily concerned with limiting the protectionist actions of importing countries, it has also established a Code of Ethics for International Trade in Food. This states the ethical obligation of food exporters not to export below standard food products to developing countries, which may not have the monitoring capacity to screen imports. However, beyond the force of moral suasion, Codex lacks the means to enforce or punish violations of its code.

The technical and scientific nature of Codex negotiations have limited the potential for politicized conflicts. However, Codex may be placed under more pressure in the future. Such contentious topics as food safety, veterinary drug residues, animal hormone residues, food product labeling, and even food advertising and marketing, are likely to come to the fore. The relatively hard scientific ground of earlier discussions will predictably soften and muddy as country representatives argue about risk perceptions and consumer rights to labeling and fair advertising.

Product Standards, Processes Standards, and Process Externalities

A contentious issue in standards disputes is negotiating the equivalence of product standards and process standards. Traditionally, process standards have been a means of ensuring certain product characteristics; for example, specific meat storage and curing processes are required to ensure that the end product is of a certain wholesomeness and a specific taste. Environmental process standards, in contrast, are concerned with regulating the external environmental effects of the process rather than the characteristics of the end product. Restricting the import of goods which are produced by objectionable processes, even though the goods are acceptable under national treatment criteria, can be viewed as an attempt by one country to dictate the domestic affairs of another.

The GATT allows countries to ban the import of dangerous, hazardous or objectional goods.[5] These bans are essentially product standards with zero tolerance. The international ban on trade in ivory, which commenced in 1990, is an example of restricting trade in a good to discourage an objectional practice. In this case, hunting for elephants for tusk ivory is the objectionable practice, endangering the survival of African elephant herds.[6] Because the ban applies to all ivory, without regard to how tusks are harvested, it cannot be considered a process standard.

Protests over the high kill rate of dolphins from net fishing for tuna resulted in the United States outlawing this method of fishing. U.S. fishing fleets adopted other, more costly but more dolphin-friendly methods of fishing to comply with the law. Foreign fleets, which are beyond the domain of U.S. regulations, continued to employ purse seine nets. In 1988, the Marine Mammal Protection Act was amended to allow a ban on the import of yellowfin tuna harvested by the purse seine nets. Yellowfin tuna harvested by other methods with acceptable dolphin kill rates can be imported. This ban is not equivalent to a product standard with zero tolerance; rather, it discriminates on the basis of process and production method. Mexico took the ban to the GATT for resolution and the GATT panel voted 35 to 1 to uphold the Mexican complaint, with the United States casting the minority vote. The tuna case hangs awkwardly over a gap in the GATT, since, as described earlier, the GATT Standards Code does not explicitly cover PPM issues. When it does try to resolve PPM issues, it does so by trying to find an equivalence with a product standard. But because there is no way to distinguish a yellowfin tuna which is harvested with an acceptable dolphin-kill rate from one harvested with an unacceptable dolphin-kill rate, equivalence is impossible.[7]

Mexico, in the interest of greater U.S.-Mexican economic relations, has not forced the GATT issue further. However, other disputes of this nature are currently being contested.

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[5] Article XX(b).

[6] There is a strong economic case that the ivory ban actually increases the likelihood of extinction, see Anderson and Leal (1991) and Block (1990). Sands (1990b) and Handl (1989) cover the ban in the context of international trade law; and investigative journalist Bonner (1993) argues that the ivory ban is a fund-raising tactic by environmental groups and has no economic or environmental validity.

[7] Pearce (1993) analyzes several recent Article XX (b) and XX (g) GATT cases, also see Charnovitz (1992).

An interesting example is the EC resolution in 1994 to ban the import of fur from countries which allow the use of leghold animal traps. As the United States allows leghold traps and will be adversely affected by this ban it has protested the regulation. A U.S. GATT case against the EC can be argued on the same legal grounds as the Mexican GATT case against the United States on yellowfin tuna.

The legal background to this kind of trade restriction is mixed. International environmental agreements have directly or indirectly advocated the use of trade and environmental standards to limit the use of objectionable processes. Principle 21(b) of the 1982 World Charter for Nature encourages governments to "establish standards for products and manufacturing processes that may have adverse effects on nature, as well as agreed methodologies for assessing these effects." This is the Codex method. The Charter advocates four types of standards: quality standards, which would regulate water and air quality; emission standards, uniform for firms in particular industries; process standards, more restrictive than emission standards, as they reduce the set of admissible technological processes firms may employ, and product standards, including the composition and packaging of products. The recent Montreal Protocol on Substances that Deplete the Ozone Layer requires all signatories to refrain from trade in chlorofluorocarbons (CFCs) and products which contain CFCs with countries which are not signatories.[8]

The use of trade restrictions to force trading partners into compliance with domestic environmental preferences is contrary to the principles of GATT. However, as Charnovitz has noted, there may be a precedent for such restrictions in the use of trade policies linked to international labor standards. The United States banned the import of goods produced by prison labor as early as 1890, and such bans were common in industrialized countries under the League of Nations. As the GATT only governs the kind and degree of trade restrictions countries can impose, it cannot ban trade in goods produced by prison labor; rather, it allows countries to ban the imports of such goods unilaterally.

Several countries impose or advocate restrictions on goods produced by child labor, and the United States makes trade preferences for developing countries contingent upon adequate labor laws, such as collective bargaining and minimum age restrictions. The Uruguay Round of the GATT does not consider the interdependence of national labor regulations and trade, although many countries, including the United States, advocated the inclusion of labor standards in the current GATT round. The counterargument is that labor laws, despite their trade effects, are the domain of the International Labor Organization (ILO). While labor regulations are not formally under the purview of the GATT, inadequate labor rights are viewed as legitimate grounds for trade restrictions.

Similarly, many politically based trade embargoes and sanctions have been deemed permissible by large coalition of countries, such as the embargo on Rhodesia (1965-80), and the various trade sanctions on Iran, Iraq, Israel, the Republic of South Africa, Serbia, and the USSR. The fact that such embargoes are not in the spirit of the GATT has not limited their support. The weight of world opinion, usually expressed through the United Nations General Assembly and Security Council, has political precedence over the GATT.

Since the end of the cold war, the U.N. General Assembly has ceased to be polarized by bloc voting. Consensus is now easier to obtain, and there is a clear trend toward U.N.-backed intervention to resolve problems which had earlier been considered domestic issues. It is not difficult to see how the threat of famine or widespread violations of human rights might galvanize international public opinion into action. Whether the global environment or the rights of nonhuman species will attain the critical mass of international public support needed to legitimate breaching a country's sovereignty remains to be seen. The uncertainty surrounding the causes and incidence of environmental externalities will tend to inhibit international consensus.

The most likely means of enforcing the environmental preferences of one coalition of countries over another is through coordinated unilateral economic actions. The ban on ivory, whatever its merits, is an example of a coalition using the stick in an effort to improve the environment. The grant or removal of trade preferences (from industrialized countries to developing countries) is a common means for inducing a trading partner to change its policies. Under most circumstances, these actions are admissible under GATT; however, trade policy is a rather blunt instrument with which to fine tune a trade partner's domestic policies. Often targeted

[8] Kiss and Shelton (1991).

nations must comply by resorting to command and control type environmental policies. Debt-for-nature swaps, where an interested party effectively pays a country to undertake some environmental actions, is a more direct and transparent means to the end. More time needs to lapse before one can judge how well debt-for-nature or cash-for-nature swaps are enforced. It is beyond the scope of this article to present the merits of market based environmental policies which rely on the assignment and security of property rights over regimes which attempt to command and control environmental quality.[9]

Preferential Trading Arrangements and Environmental Standards

Although there is no supersovereign arbiter of international effects of environmental laws, there are several preferential trading arrangements that have had to develop means of arbitrating disputes among member countries. Environmental standards are a potential area of conflict when countries attempt a mutual reduction in trade barriers. Generally, the countries with highest environmental standards believe that their standards will be reduced to the lowest standard of any member country, while the countries with the lowest standards fear that they will have to raise their standards to the level of the strictest member. This was a concern in the negotiations on the North American Free Trade Agreement (NAFTA). The experience of the European Economic Community (EC), probably the most ambitious integration of national economies, shows that the harmonization of environmental and other regulations rarely results in the acceptance of the highest or the lowest of preharmonization standards. Like CODEX, the EC has tended to adopt a minimum standard, and the regulatory process tends to move minimum standards toward the middle ground.

The problem of reaching unanimous approval is avoided by making decisions by qualified majority voting: that is, more than a simple majority, for example a 10-2 or 9-3 vote. Importantly, countries wishing to impose standards above the minimum are allowed to do so. As most regulatory bodies have representatives of all affected groups, negotiation toward a mean standard is expected; the qualified majority vote method effectively prevents extreme views from dominating.[10]

The environmental laws of the European Community are seen by many legal scholars as a possible model for international environmental law.[11] The perennial problem is that the enforcement of such laws requires some surrender of national sovereignty to an international body. The Single European Act (SEA) of 1987 makes the European Court of Justice the final authority when EC trade policy and environmental policy clash. Article 30 of the SEA governs the free movement of goods in the EC; it outlaws "all trading rules enacted by member States which are capable of hindering, directly or indirectly, actually or potentially, intraCommunity trade." Article 100 of the SEA governs harmonization of community standards at a high base level, as discussed in the previous paragraph, with allowances for higher national standards. These two articles conflicted in what is known as the Danish Bottles Case. Danish law requires all beer and soft-drink containers to be returnable. Other member States argued that the Danish bottle law was a violation of Article 30, as it hindered the free movement of goods. The Danes' defense was that their bottle law was necessary to protect the environment, a goal advocated by the SEA. To placate their critics, Denmark granted a quota to other member States for sales of beverages in nonreturnable bottles. The European Court of Justice ruled that the Danish quotas were a violation of Article 30; however, it also ruled that the bottle law, without quotas, was consistent with Article 30. The Court applied a proportionality test to evaluate the bottle law. Essentially, the Court concluded that the bottle law had, as its primary objective and consequence, the protection of the environment, and its environmental impact outweighed the effect of restricting the free movement of goods.[12]

The European Community, through the European Court of Justice, has devised a means of distinguishing legitimate environmental and health standards from disguised, protectionist trade restrictions. Still, the method is more subjective

[9]Anderson and Leal (1991) is a readable presentation of the case for recognizing and working with market forces in the construction of environmental policy, rather than disregarding them.

[10]McGee and Weatherill (1990), Burrows (1990) and Jackson (1989a) on harmonization, Sexton (1990) on auto emissions, and Peltzman (1976) on the lack of extremism in standards setting. The Economist article "Eurononsense", despite its critical title, is a rather sympathetic and humorous discussion of the harmonization of product and process standards in the European Community.

[11]Weiler (1991), Sands (1991), and Hahn and Richards (1989).

[12]Kromarek (1990), Sands (1990a).

than objective. It remains a contentious process in the European Community, where economic and social standards are virtually homogeneous relative to the rest of the world. Dispute resolution may be even more difficult when divergent North-South interests clash.

Conclusion

The use of trade restrictions to influence the environmental, safety, or even the labor standards of trading partners is likely to lead to further trade disputes. Neither the GATT nor other international negotiation fora has the authority or enforcement capacity to resolve such disputes conclusively. Support for such trade restrictions can often come from both environmental groups and traditional protectionist interests. When these two motives are mixed, it is difficult, if not impossible, to determine whether such restrictions are primarily protectionist or green. Environmental, health, safety, and the asserted rights of nonhuman species are also issues which may obtain sufficient support by international public opinion to overrule the liberal trade direction of the GATT. This potential conflict is not likely to be solved quickly or quietly. It will be an issue to watch for in the news and in the next GATT Round.

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Chapter 7

Agricultural Trade and the Environment: Some Basic Economic Principles

Denice Gray and Barry Krissoff

In this paper, we explore the effects of changes in policy on agricultural production, consumption, trade, and the environment. Three types of policies are discussed: those aimed at domestic environmental problems, agricultural trade liberalization policies, and policies targeted at transboundary or international environmental problems. From these three cases, one may infer the economic considerations underlying many of the following chapters.

Introduction

Our objective is to discuss some basic economic principles linking agricultural trade and policy and environmental quality and policy. We begin by introducing the concepts of externality and optimal tax. These two concepts link economics, environmental side effects, and policy.

We then address three relationships. First, we examine how domestic environmental policies affect production, consumption, and international trade. Governments initiate environmental regulations or taxes to encourage less of a polluting activity, but the level and composition of economic activity often are influenced as well.

Second, we evaluate how liberalizing agricultural policies affects environmental quality and global trade. Much attention in the agricultural literature has focused on the effects on production, consumption, and trade of multilateral, regional, and unilateral reform of the agricultural sectors, but far less attention has been centered on the effects on the environment. In this section, we illustrate how the removal of producer support affects trade between two countries and environmental quality in each country.

Third, we explore how environmental policy aimed at reducing pollution that crosses national boundaries affects international trade. Effluents of one nation flowing across its borders and damaging its neighbors or the global commons has been of much concern in recent years. Carbon dioxide and nitrous oxide, for example, are emitted as byproducts in some agricultural production processes and contribute to the "greenhouse effect." In this section we discuss how a trade policy can be a second-best solution in reducing a global environmental problem.

An Introduction to Externalities and Optimal Policies

Economists use the term externality to describe a harmful or beneficial side effect that occurs in the production, consumption, or distribution of a particular good. Production of an agricultural good may generate an environmental externality, for instance. To produce the good, a farmer chooses a technology and input mix (land, labor, machinery, and chemicals) in order to maximize profits. In the production process, wastes may be produced as a byproduct. These wastes are an environmental externality if they affect others in some way and the farmer does not pay compensation for the costs of the waste cleanup. For example, cattle may produce manure in greater amounts than can be absorbed into the local environment or a pesticide residue may flow into nearby water supplies.

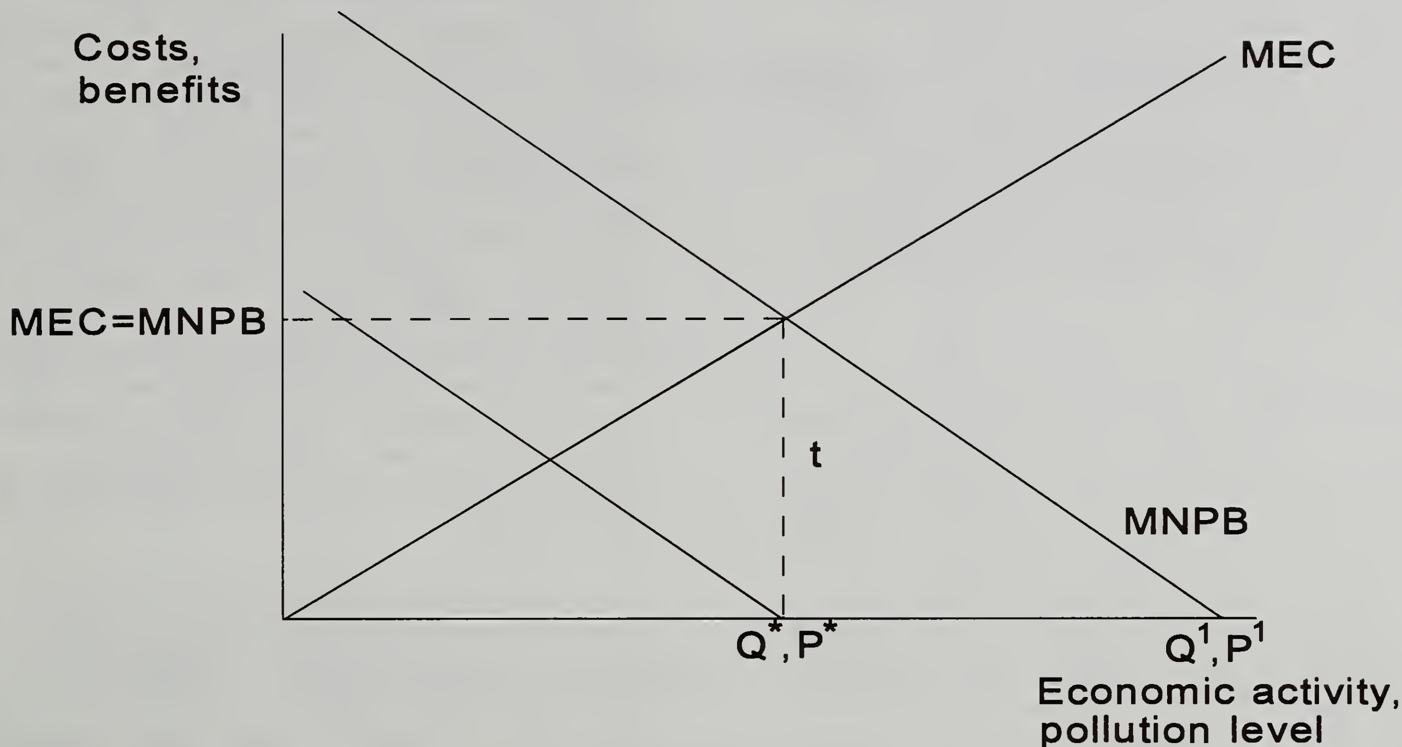
An externality often occurs when there are no clearly defined and enforced property rights. This is particularly true when a community, or nobody, owns resources such as ground and surface water and air over a city. Externalities also tend to occur when the victims of pollution are more widely dispersed and difficult to identify (Pearce and Turner). The market fails to reflect the cost to the community of the externality.[1]

Agricultural practices can cause various externalities. Farmers do not bear all the costs

[1] Market failure would not exist if the bad generated in the production process affected only a next-door neighbor and there were clearly defined property rights. The producer and the neighbor could privately negotiate a payoff to reduce the level of the bad and an efficient solution could be attained. Whether the producer pays the neighbor or the neighbor pays the producer depends on who owns the property rights associated with the offending pollutant.

Figure 1

Optimal pollution level and tax



associated with agricultural production, such as soil erosion, water depletion, surface and groundwater pollution, deforestation, loss of wildlife habitat, and chemical misuse and contamination.

Governments may attempt to reduce pollution through market intervention. Policymakers generally have a choice of two types of environmental policies: a market-based approach or command-and-control. A market-based policy relies on creating incentives to reduce the externality. For example, a unit tax on effluents such as nitrates gives polluters a financial incentive to reduce their discharges. The tax rate could be set higher or lower, depending on the desired effluent level. Other market-based approaches include subsidies to encourage environmentally-friendly production practices, taxes on the good rather than the effluent, and taxes on a polluting input. In The Netherlands, for instance, the Government taxes manure that exceeds what can be recycled on the farm. Germany provides financial incentives to its farmers for specific resource conservation and preservation measures, such as leaving meadows unplowed or caring for hedges, woods, and thickets.

Under a command-and-control approach, the Government restricts or bans the use of a polluting input or production practice. Because it is so difficult to measure effluents and monitor market-based approaches, policymakers often prefer command-and-control policies, which are easier to design and oversee. The approach in the United States to the control of surplus manure is technology-based regulations. Livestock operations over a certain size must construct facilities for pollution abatement. U.S. agricultural producers face regulations on the use of pesticides. Federal policies delineate, by crop, the particular compounds, timing, and amounts of allowable pesticides.

In order to determine the ideal or optimal level of pollution, we need to know the value society places on the damage from pollution, such as that associated with contaminated water or carcinogens in the air, and the net benefits from production at different levels of economic activity. Following Pearce and Turner, these damages and benefits can be represented by the marginal external cost schedule (MEC) and the marginal net private benefit (MNPB) schedule in figure 1. The MEC curve measures the additional costs of pollution to society from changes in production levels. We

draw the MEC as upward sloping to reflect the greater per unit cost from environmental damage at higher levels of economic activity. The MNPB schedule shows the benefits, minus private costs, flowing to the producer from differing levels of production. Ignoring the social costs of production, the producer would choose to produce at level Q^1, with an associated level of pollution P^1, levels higher than the societal optimum. Society's optimal level of economic activity, and the associated level of pollution, occur at that level of production where the marginal net benefits to producers equals the marginal costs of pollution to society, or Q^*, P^*.

Society could opt to eliminate most, if not all pollution, but the cost of doing so may well exceed the benefit. For example, all pesticides could be banned from use on agricultural products, but this could drastically reduce the food supply, or make it very expensive. The output and pollution level, in such a case, would be less than Q^* and P^*. A more economically rational approach is to compel the producer to pay an amount equal to the costs of the pollution. A tax on production, such as t in figure 1, would accomplish such a goal. If a policy imposes a tax of rate t on each unit of production, then the producer's marginal net benefit curve shifts downward, and production occurs up to point Q^*, the point at which the marginal net benefits from production equal zero. The optimal tax is that tax rate that produces a level of economic activity and pollution at the social optimum, Q^* and P^*. This tax is considered optimal because it eliminates the gap between private and social costs.

Environmental Policies to Curb Domestic Pollution and Their Effect on Trade

How does an externality tax affect production, consumption, trade, and prices? Consider the three-panel diagram in figure 2, which illustrates an exporter (panel 1), an importer (panel 3), and a world market where excess supply from the exporter and excess demand of the importer determine world prices (panel 2).[2]

[2]Although conventional economic logic underlies this illustration, figure 2 and the subsequent figures have several simplifications from the complex real world. The figures assume that the world consists of two countries, that markets are competitive, and that there are no costs related to international transactions. Also, it is assumed that good W is homogeneous and that the implementation of the environmental policy does not cause changes in other prices, income, population, technology, and consumer tastes.

The panels portray an open economy where the exporting country implements an environmental policy, but the importing country does not. The exporting country may impose an environmental tax because it does not have an assimilative capacity to absorb the waste products associated with the production of good W. (By contrast, the importing country may have a resource base with greater resiliency or it may not have the same societal concerns with pollution.) The before-tax supply schedule S_p reflects only the private (or internal) costs of producing W; the after-tax supply schedule S_s reflects the full societal costs of production, which include the private production costs and the costs to society of the environmental impacts. S_p and S_s are not parallel because we assume that the unit cost of pollution increases as production increases -- the vertical distance between S_p and S_s reflects the marginal external cost schedule.

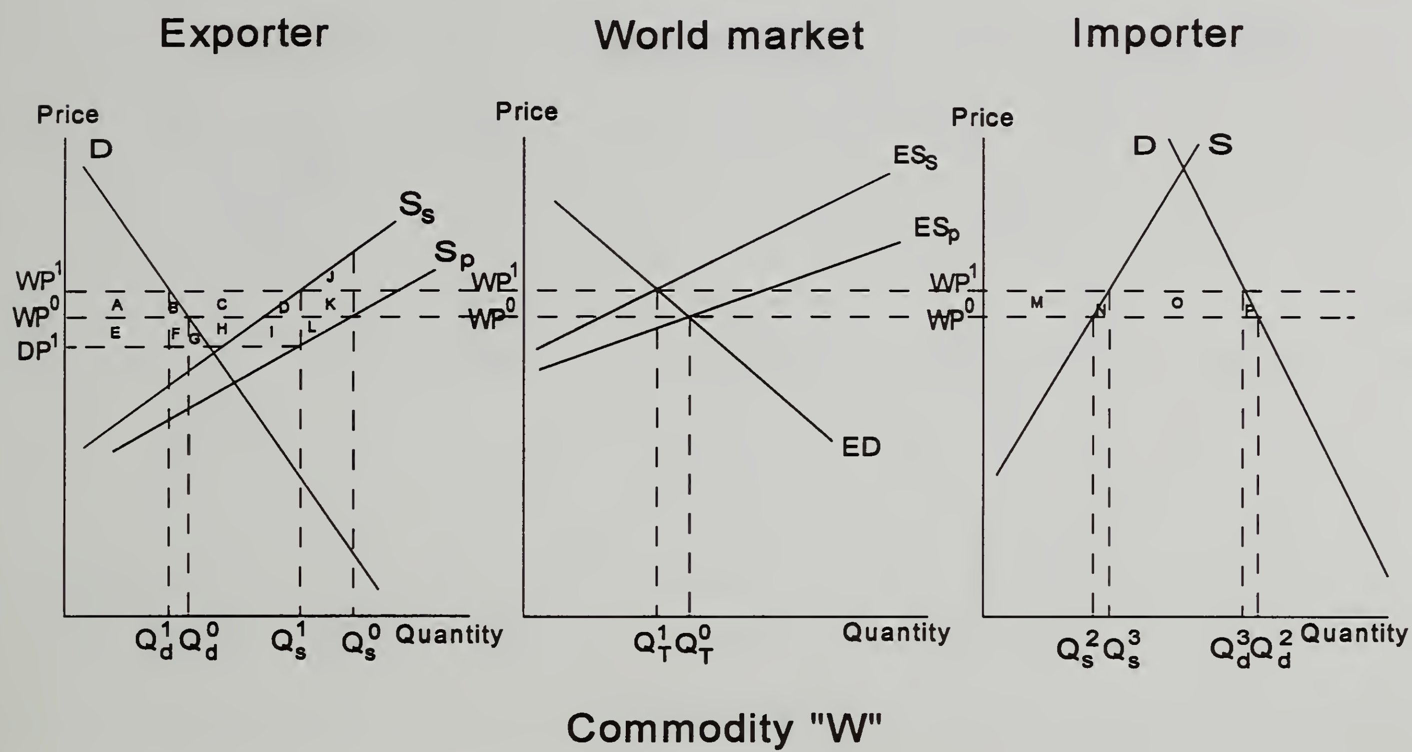
At the equilibrium world price level WP^0, the supplier is over-producing by the horizontal distance between S_s and S_p. The optimal tax internalizes to the industry the external costs of its operations. This raises industry costs, reduces the price received by the industry (WP^0 to DP^1), lowers the production level, and decreases the externality. The tax is optimal because it eliminates the gap between private and social costs at each potential unit of production.

The middle panel of figure 2 shows that the effect of dampening production incentives in the exporting country is to reduce exports to the world market, as shown by a shift in the position of the excess supply schedule to ES_s from ES_p. The effect of the shift is to reduce trade from the pretax level of Q_T^0 to the after-tax level of Q_T^1 and to shift market share toward the importing country. The exporting country's level of production declines from Q_s^0 to Q_s^1 (panel 1) and the importing country's level of production rises from Q_s^2 to Q_s^3 (panel 3).

Some of the burden of the environmental tax also falls on domestic and foreign consumers. This happens because the exporting country is large enough to cause world prices to rise (WP^0 to WP^1) when it reduces supply in response to a tax or regulation. Consumption drops from Q_d^0 to Q_d^1 in the exporting country and falls from Q_d^2 to Q_d^3 in the importing country. A small country, in contrast, would be unable to turn the terms of trade in its favor when implementing a supply-reducing environmental policy.

Figure 2

Trade and welfare effects of an optimal environmental tax on producers



An environmental policy implemented in a large exporting country also affects the welfare of market participants in both nations. Producer welfare can be measured by the area above the supply curve up until the price line. Consumer welfare can be measured by the area below the demand curve down to the price line.

In the exporting country, producers incur welfare losses equal to areas labeled EFGHIL, and consumers lose welfare equal to areas AB. However, government tax revenue (tax rate times quantity produced) increases, as represented by areas ABCDEFGHI, and the costs of the pollution externality (the gap between S_s and S_p) generated in the production of W falls by areas JKL. On net, the exporting country is better off by areas CD (terms-of-trade effect) and areas JK (externality effect). Thus, while the imposition of the environmental policy in an exporting country appears likely to have trade-reducing effects, the country as a whole may still be better off, taking into account society's valuation of environmental benefits. As for the importing nation, producers benefit from the increased world price, area M, but consumers incur welfare losses, areas MNOP. On net, world welfare changes by (JK less B, N, and P), which may be a welfare gain or loss depending upon the terms of trade and level of externality.[3]

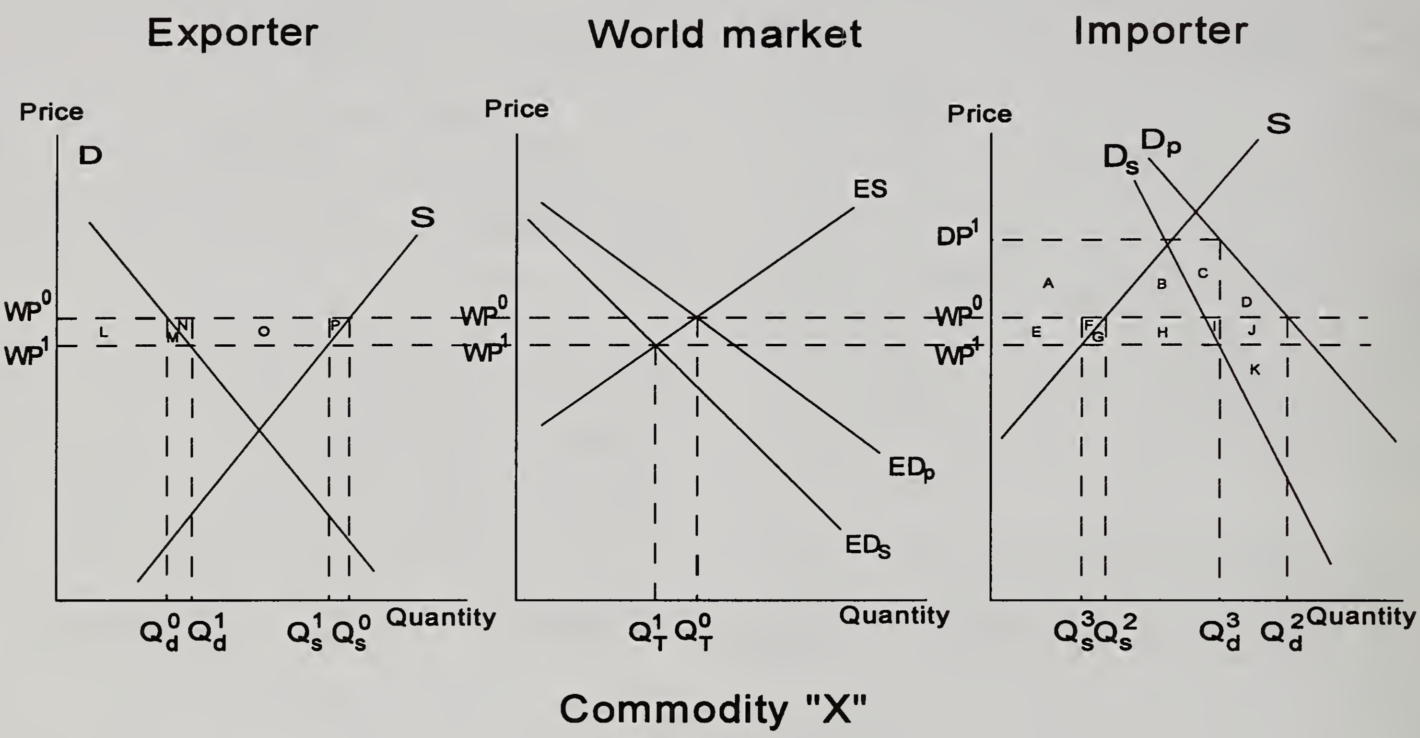
Externalities also can occur in consumption. For example, the disposal of food product packaging can be an environmental issue. The costs to society of managing disposal of packaging waste may not be captured in the market price of food products, so consumers may buy amounts of the products greater than the social optimum. This situation may lead to a legal requirement that the packaging materials be recyclable or, alternatively, a tax may be imposed on consumption of the product. A consumption externality and the trade implications of a tax designed to mitigate the impacts of an externality in the importing country are shown next.

In figure 3, the curves D_p and D_s for the importing country represent private and social costs of consumption (panel 3). The optimal consumption tax eliminates the gap between the two demand curves. The domestic demand shift triggers a reduction in demand for the imported product as

[3]The change in world welfare is equal to CD+JK-NOP = JK-B-N-P, since BCD=O.

Figure 3

Trade and welfare effects of an optimal environmental tax on consumers



well, which is indicated by the leftward shift in the excess demand schedule from ED_p to ED_s (panel 2). As a consequence, exports fall from Q_T^0 to Q_T^1. In addition to curtailing consumption, the tax generates funds that could be used for waste management or recycling activities.

As in the case of the production externality, the environmental policy affects the welfare of market participants in both countries. In the importing country, consumers' welfare falls due to higher domestic prices (DP^1), producers' welfare falls due to lower world prices (WP^1), but the tax revenue gain (areas ABCEFGHI) and the reduction of the externality (areas DJK) more than offset these losses. The importing country realizes a net welfare gain of areas GHI (terms-of-trade effect) and JK (externality effect). In the exporting country, producers lose areas LMNOP and consumers gain areas LM, so there is a net welfare loss because of the deterioration of the terms-of-trade. As in the case of the production tax, the change in global welfare is ambiguous, as it depends upon the level of externality and the terms of trade.[4]

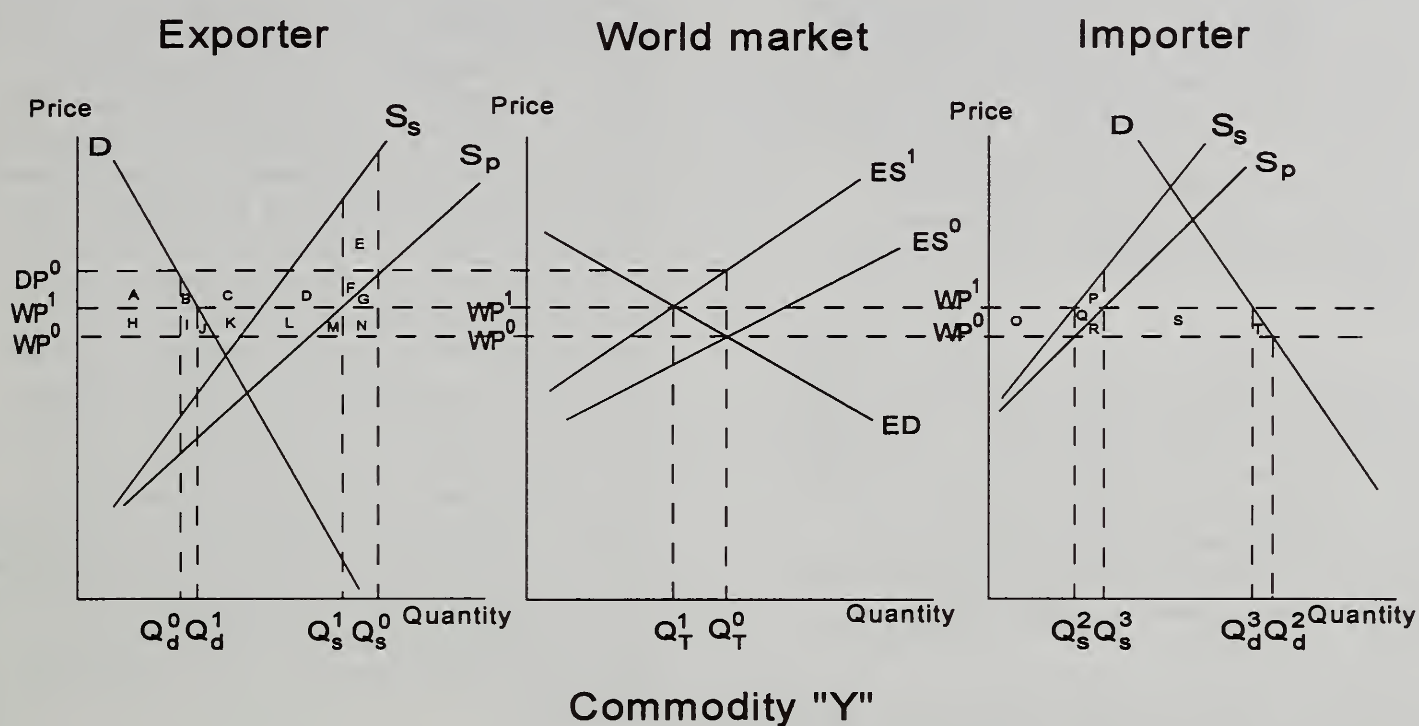
[4]Global net welfare changes by JK less F, N, and P, since FGHI=0.

Liberalization of Agricultural Policies and the Effects on the Environment

Just as environmental policies can affect agricultural production and trade, agricultural and trade policy can affect environmental quality. Government intervention in agriculture can contribute to environmental degradation or protection. In developed countries, support for producers in the form of guaranteed high prices for some commodities and input subsidies encourages overproduction and specialization (Tobey and Reinert; Anderson and Blackhurst). Land in agricultural production often increases, which may lead to the use of fragile soils and overuse of water resources. Furthermore, producer support tends to be for commodities with certain characteristics: those produced with row cultivation, tending to cause soil degradation; those that require large amounts of irrigated water; and those that receive intensive chemical applications (Tobey), perhaps leading to over-application of fertilizers and pesticides, and water pollution.

On the other hand, some developed countries have policies that promote environmentally friendly farming or that seek to harmonize economic and environmental goals, such as the U.S.

Figure 4
Trade liberalization and environmental quality in an open economy



Conservation Reserve Program and the European Community's Nitrate Directive. These policies can provide benefits to the environment.

In developing economies, governments often keep food prices artificially low to subsidize urban consumers. Partly to compensate producers, governments frequently subsidize inputs (Krueger, Schiff, and Valdes). Subsidization of fertilizers and pesticides has led to increased use, undercharging for irrigated water has caused water depletion, and distorted tax and land tenure policies have encouraged deforestation. Recently, some developing countries have begun to address the environmentally harmful side effects of their policies. For instance, Brazil has rescinded their tax, credit, and tenure polices that encouraged deforestation of the Amazon region, and Indonesia has removed its large subsidies for pesticides, which had caused a reduction in the natural enemies of pests and the development of pest resistance.

In short, domestic policies, usually implemented with trade and domestic policy instruments, affect the commodity composition of production, input use, and production techniques within and across countries. International trade flows and environmental quality thus also change.

Over the last decade, there have been calls, particularly in the developed economies, for liberalization of agricultural trade. Trade liberalization involves the reduction or removal of trade barriers and domestic agricultural support policies. Figure 4 shows the effects on production, consumption, trade, and the environment of liberalizing trade in a two-country, open economy case. Initially, the exporting country supports its producers through an export subsidy. This policy causes the domestic price in the exporting country (DP^0, panel 1) to be higher than the world market-clearing level (WP^0), and the amount of trade to be $Q_T{}^0$ (panel 2). (We assume that the importer has no domestic policies either supporting or taxing its producers.) Given the export subsidy in the exporting country, the importing country purchases from abroad $Q_T{}^0$ at price WP^0.

First, let us examine the case in which production of commodity Y causes no pollution in either the exporting or importing country, so that the S_p curves incorporate all the costs of production. If the exporting country decides to remove its export

subsidy, then domestic prices fall, production is discouraged, and the world market price rises to WP^1. The exporting country produces less (Q_s^0 to Q_s^1) but consumes more (Q_d^0 to Q_d^1), so the level of trade falls (Q_T^0 to Q_T^1). Trade liberalization increases consumer welfare by areas AB, reduces producer welfare by areas ABCDF, and decreases government expenditures by BCDFGIJKLMN, for a net societal welfare gain of areas BGIJKLMN. In the importing country, producers respond to the higher price by increasing production, while consumers demand less, so that imports fall. Producers gain welfare of areas OQ, while consumers lose areas OQRST, for a net welfare loss of RST.

Second, we examine the case in which production of commodity Y causes domestic pollution in both the exporting and importing countries. We assume that the exporting country has a lower assimilative capacity for pollution than the importing country, so the marginal external cost associated with production in the exporting country is greater (the vertical distance between S_s and S_p is larger in panel 1 than panel 3).

The exporting country decides to liberalize its trade by removing its price-distorting policies and both countries choose not to impose an environmental policy that would incorporate the external costs of production in the producers' decisionmaking process. Then, as before, production falls and consumption increases in the exporting country. However, now, there is a further gain in welfare from trade liberalization due to the reduction in pollution. The net welfare gain for the exporting country is areas BGHIJKLMN (trade liberalization efficiency effect) and trapezoid EF (reduction in the externality costs). The importing country, on the other hand, increases its level of production and the associated pollution. Its welfare now decreases by RST (consumer loss less producer gain) and PQ (externality effect), due to the policy change in the other country. Since trapezoid EF is greater than PQ, net pollution declines-trade liberalization improves global environmental quality.[5]

[5]This result hinges on the assumption that production falls in the country with the relatively more-polluting production. Besides affecting quantities traded and prices, trade liberalization may affect input use and therefore, environmental vulnerabilities with respect to soil erosion, chemical use, water quality, and so forth. Trade liberalization also may encourage pollution sparing technological change. See Anderson (chapter 8) for a depiction of these effects.

Environmental Policies to Curb Transboundary Pollution and Their Effect on Trade

Above, we assumed that domestic pollution does not cross national borders. However, there are cases of transnational pollution. Effluents of one country can flow across national borders and damage neighbors or the global commons. The felling of forests for conversion into cropland, for example, increases the release of carbon dioxide into the atmosphere and may contribute to the greenhouse effect. Fertilizers emit nitrous oxide and rice paddies and ruminant animals emit methane, both greenhouse gases (Lean and coauthors). In the long run, a warming of the world climate could alter agricultural production patterns in many countries. Chemical use on farmland or erosive production practices could pollute water used as an input in downstream countries, such as those along the Danube River in Europe. Other kinds of international spillovers are primarily ethical, such as cruelty to animals or indiscriminate destruction of wildlife habitat (Blackhurst and Subramanian, in Anderson and Blackhurst).

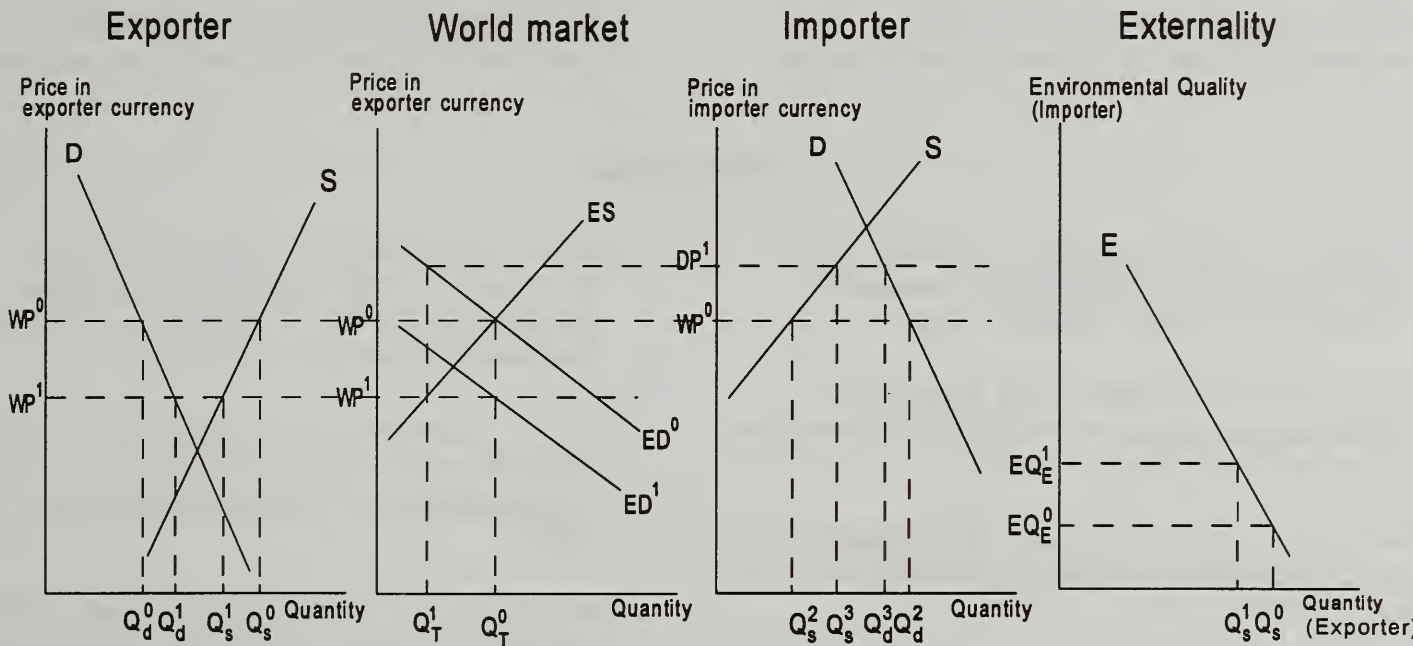
When international cooperation can be achieved to control transnational pollution or pollution to the global commons, the conceptual analysis described above for domestic policy can be applied to the international setting. Each country could apply an optimal tax reflecting the level of externalities emitted from that country and its effect on neighboring countries and the global commons. This optimal tax would maximize world social welfare.

International cooperation in controlling transboundary pollution is difficult to achieve, however. Furthermore, no country, acting alone, has an incentive to incorporate the costs of its worldwide environmental damage. Such a policy increases the costs to domestic industries, but brings no extra social benefits. The first-best policy of optimal taxes that maximize global welfare is, therefore, often not possible.

Acting unilaterally, a country can implement a second-best policy of a tariff on an import whose production generates transboundary pollution. This tariff is a second-best policy if the country imports the polluting good, is a recipient of the transboundary pollution, and is large enough for its tariff to influence prices and production in the polluting country (Baumol and Oates). This tariff is

Figure 5

Imposition of tariff to control transboundary pollution



Commodity "Z"

not equivalent to the first-best policy, since prices in the polluting country are only indirectly affected by tariffs, so that, more than likely, consumer prices will be lower in the exporting country than if optimal taxes incorporating worldwide externality costs were imposed.[6] Also, the tariff will only account for the costs of the externality within the importing country. In a multicountry world, consumers in the tariff-imposing importing country will not have to pay the full costs of their consumption.

Figure 5 shows the two-country, open economy case, along with an additional panel illustrating a transboundary effluent. Production in the exporting country does not affect environmental quality at home but does generate externalities in the importing country. The production of Z in the exporting country and the level of environmental quality in the importing country have a negative monotonic relationship in panel 4. In the absence of international cooperation, the importing country may choose to impose a tariff to mitigate the pollution concern. The tariff would cause the domestic price in the importing country to rise (WP^0 to DP^1, panel 3) and the level of imports demanded to fall (panel 2). The excess demand curve shifts downward (ED^0 to ED^1), lowering world price and the price in the exporting country (WP^0 to WP^1, panel 1). Production in the exporting country drops (Q_s^0 to Q_s^1), and the associated externalities affecting the importing country decline (environmental quality increases from EQ_E^0 to EQ_E^1). The tariff has thus reduced transboundary externalities.

Summary

In this paper we have explored three conceptual linkages between agricultural trade and the environment. Both agricultural production practices and food consumption can cause environmental externalities. We established that policies designed to reduce these externalities can have an impact not only on the domestic market, but also on international trade and therefore, the competitiveness of agricultural commodities. Second, domestic agricultural and trade policies can affect the environment. We demonstrated that, contrary to some thinking, trade liberalization

[6]For example, in figure 2 above, the consumer price in the exporting country increases following the imposition of an optimal tax (WP^0 to WP^1). In figure 5, the consumer price falls in the exporting country due to the imposition of a tariff (WP^0 to WP^1).

might improve global environmental quality. Finally, domestic production or consumption can have environmental implications in foreign countries. We demonstrated that a tariff can be used to control transboundary pollution, although this is generally a second-best strategy. These three cases explain the basic economic considerations underlying many of the following chapters. Leuck (Chapter 11) and Forsythe and Evangelou (Chapter 10) explore the effects of environmental policies on production and trade. Anderson (Chapter 8) investigates the effects of a regional trade agreement on environmental quality. Finally, Ballenger and coauthors (Chapter 9) and Haley (Chapter 12) discuss the coordination of environmental, agricultural, and trade policies.

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Chapter 8

NAFTA and Environmental Quality: Issues for Mexican Agriculture

Margot Anderson

This chapter discusses how freer trade between the signatories to the North American Free Trade Agreement (NAFTA) affects longer-term agricultural environmental issues for Mexico. The discussion addresses these issues in Mexico and the United States, and projected environmental consequences of NAFTA. Even if NAFTA doesn't significantly increase or decrease the rate of environmental degradation in Mexico, environmental issues will require attention.

Introduction[1]

The relationship between freer agricultural trade and environmental quality is only beginning to be understood. While freer trade can lead to increased economic efficiency and economic growth, these gains neither guarantee improved environmental quality nor necessarily create environmental degradation. The effect of freer trade on agricultural resources depends on changes in production levels, inputs use, technical change, and, in the longer run, the impact of economic growth on the demand for environmental quality.

Understanding the agricultural environmental effects of freer trade is critical for all countries undergoing policy reform, but is particularly important in poorer countries. These countries often have large agricultural sectors, less abundant natural resources, less income to devote to resource conservation, and agricultural programs that often discourage environmentally positive production practices. Also, in poorer countries, trade reform can lead to relatively larger changes in trade, production, and economic growth, with relatively larger coincident environmental impacts.

The North American Free Trade Agreement (NAFTA), which will liberalize trade in goods and services and lead to reformulation of investment policies for the United States, Mexico, and Canada, provides a good illustration of the interaction between trade reform and agricultural, environmental quality. In the short to medium term, removing tariffs on traded agricultural goods will alter trade flows and affect crop mix, regional production and input use. These results, in turn, affect such environmental factors as water quality, soil erosion, wildlife habitat, and food safety. Other agricultural, environmental impacts may occur under NAFTA-induced changes in investment rules; for example, a more liberal investment climate in Mexico could encourage an expansion in agricultural processing, which can contribute to surface and groundwater pollution.[2] NAFTA will also increase Mexican wage rates, which will influence crop production and input use in Mexico.[3]

Most discussions of the environmental effects of NAFTA have focused primarily on two broad issues. First, concerns are raised about pollution along the U.S.—Mexico border, such as air pollution, water contamination, and production of hazardous wastes. Polluting border activities are primarily associated with industrial production. Although border pollution has received considerable attention, agriculture is not the predominant sector on the border, and any effort to regulate border activity within NAFTA will have relatively less effect on agricultural production and processing. Some border concerns that do affect agriculture have already been addressed by various

[1]I would like to thank Nicole Ballenger, John Dunmore, Ken Forsythe, Donna Roberts, Jim Tobey, and Constanza Valdes for their helpful comments and suggestions.

[2]Food processing wastewaters can contain pollutants such as suspended solids, biochemical oxygen demand, nitrogen and phosphorus. Other wastes that can contribute to pollution of surface and groundwater include unusable parts of raw products (Kirk, 1985). In 1985, U.S. "wastewater loads from fruit and vegetable processing plants was estimated at about 20,000 cubic meters (5.3 million gallons) per day daily loads of biochemical oxygen demand and suspended solids (the major pollutants) of about 10,000 kilograms (22,000 pounds)" (Kirk, 1985). In the United States, there are Federal and State laws regulating wastewater discharges.

[3]Higher wage rates can reduce the profitability of using environmentally sensitive marginal land for agricultural production.

treaties.[4] Other border issues are addressed in the environmental side agreement—the North American Agreement on Environmental Cooperation, which was signed by President Clinton in September 1993. The agreement, which was supported by numerous environmental groups, requires, *inter alia*, each country to ensure that its laws provide for high levels of environmental protection and creates a trinational Commission for Environmental Cooperation, designed to foster environmental cooperation and settle environmental disputes.[5]

The second issue is the harmonization of environmental standards and includes defining and enforcing them so that they are not used improperly as trade barriers. Harmonization of food safety and health standards on traded goods is being pursued within the NAFTA. Currently, all commodities imported into the United States must meet U.S. food safety regulations, and the United States has stated that these regulations will not be altered under NAFTA and would only be altered "on the basis of scientific review" (USTR, 1991).

One feared consequence of dissimilar environmental standards is that countries with relatively lax standards (or enforcement) will specialize in the production of pollution-intensive goods. For example, concerns are raised that U.S. standards for water and soil quality and food and farmworker safety impose compliance costs on U.S. farmers. Because of lower environmental standards in Mexico, Mexican producers benefit from a cost advantage, based on environmental regulations or standards. "Equalizing" these costs across borders could require process standards (as opposed to standards on products, such as measurable pesticide residues in food), which are difficult to implement and enforce and have questionable economic rationale.

While border pollution and environmental standards can be at least partly addressed within the context of a trade agreement and side agreements, other environmental concerns related to free trade are less negotiable. Of particular concern are the longer term effects on the structure of Mexican agriculture, changes in Mexico's crop mix, the intensity of chemical use, and land management, all of which can have environmental implications.

Agricultural Policies, Trade Policies, and Environmental Quality

It is well known that agricultural production can adversely affect environmental quality by depleting or contaminating water supplies, increasing soil degradation, and increasing deforestation (see **Box-What is Environmental Quality?**). Some adverse effects are attributed to agricultural and trade policies that distort input and output prices. Price distortions can affect crop mix, the location of production, and input use, which have direct and indirect effects on environmental quality (Miranowski, Hrubovcak, and Sutton, 1991). For example, high-income countries typically protect farmers by raising domestic prices relative to world prices. These higher prices can encourage chemical use, mechanization, and land conversion, all of which can have negative environmental consequences. Poorer income countries typically protect consumers through low food prices that effectively tax farmers and discourage production, which can be environmentally positive by holding production below its free-market level. Many countries, regardless of income level, provide input and credit subsidies that can encourage overuse of agricultural chemicals and overinvestment in agriculture. Of course, environmental degradation can also occur in the absence of government support if commodity prices do not fully reflect the negative effects of agricultural production. Free trade prices are not a panacea for environmental degradation because these prices do not internalize environmental costs. Because of this market failure, agricultural producers and processors have little incentive to reduce activities that contribute to pollution or adopt environmentally benign technologies. Governments may need to implement environmental policies and create

[4]One agricultural border issue concerns water quality and water quantity. Several U.S. and Mexican agricultural regions rely on water originating from the upper Colorado River in the United States. In the early 1960's, an irrigation project in western Arizona began discharging highly saline waters from a new drainage system and Lake Powell, the reservoir behind Glen Canyon Dam, reduced water supplies needed to dilute salts downstream. These two events reduced both the quality and the quantity of water to those receiving Colorado River supplies in Mexico and in parts of the United States. As a consequence, the United States constructed treatment plants to control salinity released to downstream users (see Gardner and Young, 1988, for further discussion).

[5]Policy instruments to manage border pollution are not generally components of trade reform. However, because of the severity of pollution along the U.S.-Mexico border, transboundary pollution is a NAFTA issue and is the impetus for the pressure to negotiate an environmental "side (or supplemental) agreement" to the NAFTA. Side agreements are parallel legislation that "seek institutional reforms that would ensure that environmental interests are incorporated in the formulation of trade policy, and they seek a new dispute settlement mechanism ... for dealing with environmental issues." (Hufbauer and Schott, 1992).

What is Environmental Quality?

- In agriculture, environmental quality is defined in terms of soil and water quality, and land use.
- Soil quality can be defined by several factors, including nutrient availability, organic carbon, texture, water-holding capacity, structure, rooting depth, and acidity (Larson and Pierce, 1991).
- Ground and surface water quality can be measured by many factors, including concentrations of nitrates, phosphorus, dissolved oxygen, turbidity, streamback stability, and deposition of sediment (Smith, Alexander, and Wolman, 1987; USDA, SCS, 1989).
- The quality of land use decisions are defined in terms of the ability to sustain long-term production, provide wildlife habitat, or sustain plant diversity.
- Because soil and water quality is often difficult (and expensive) to actually measure, approximations for actual measurements are considered. These approximations include ground and surface water vulnerability indices, which are base on purely physical data (Kellogg, Maizel, and Goss, 1993). Other proxies consider behavioral characteristics, such as cropping practices and input use.

appropriate institutions to meet environmental objectives.

Environmental Effects of Trade Reform

Trade reform, which frequently requires changes in both trade and domestic policies, is increasingly on the agenda in developed and developing countries (see **Box-What is Free Trade ?**). Countries generally recognize the potential for economic gain through increased efficiency and competitiveness, but the environmental quality effects are not immediately apparent. To examine the potential effects of trade reform on agricultural environmental quality, it is convenient to delineate them into shorter term price and market access effects and longer term growth effects.

In the shorter run, trade reform improves market access for goods previously governed by quantity restrictions (such as quotas and other nontariff barriers) and realigns prices closer to world prices. In countries (or subsectors) that have kept producer prices below world prices, freer trade can raise producer prices above prereform levels. Other things being equal, higher goods prices raise production incentives, and increase output, which, in turn, can increase any associated environmental degradation. For example, increased producer prices can lead to increased land clearing, either through deforestation or onto marginal land or more intensive use of currently cultivated lands.

Lopez (1992) argues that trade reform will increase agricultural environmental degradation in poorer countries by increasing production on the extensive margin, that is, by increasing the incentives to clear forested land and produce in marginal areas.[6] Lopez argues that, in many developing countries, trade reform changes the domestic terms of trade in favor of agriculture, that is, it raises the price of agricultural goods relative to the price of nonagricultural goods. As a result agriculture becomes more profitable, and labor and capital are attracted into the sector, causing an increase in resource-depleting activities. But it is not clear that trade reform leads to an increase in production on the extensive margin for all countries, due to constraints on land availability and relatively cheap chemical inputs that could be substituted for land. It is equally likely that a favorable shift in the domestic terms of trade toward agriculture could increase the use of agricultural chemicals with attendant food safety and water quality problems. For many countries, including Mexico, trade reform is likely to increase prices in some agricultural subsectors and decrease prices in others, further complicating the ability to generalize about the ultimate resource effects of trade reform.

Trade reform can be a positive catalyst for economic growth but again, the environmental effects are not obvious. For example, it is argued that increased production necessarily accompanies economic growth and leads to an increase in

[6]Lopez (1992) cites several case studies that indicate increasing producer prices cause farmers to increase cultivated land, which implies greater deforestation and increased biomass degradation.

What is Free Trade?

Free trade usually includes:

- Removal of deliberate tariff barriers
- Removal of such deliberate nontariff barriers as quotas
- Removal of policies that treat imported goods differently from domestic goods.

Free trade might also include:

- Removal of all policies that give any form of assistance to domestic firms.

In practice, free trade:

- Aims to eliminate policies that provide clear incentives to expand production or reduce consumption of products of interest to trading partners.

Source: Josling, Timothy. "The Treatment of National Agricultural Policies in Free Trade Areas." International Agricultural Trade Research Consortium Working Paper 92-7. June 1992.

environmental problems associated with additional output. This argument may hold over the shorter term, but in the longer run, higher income is considered positively correlated with an increase in the demand for environmental quality. And although there is empirical evidence that higher per capita income is positively correlated with a greater demand for environmental quality, these estimates are based on correlations between income and ambient emissions, the correlation between income and resource degradation (that is, deforestation, loss of soil nutrients, loss of water quality) is less clear and less quantifiable.

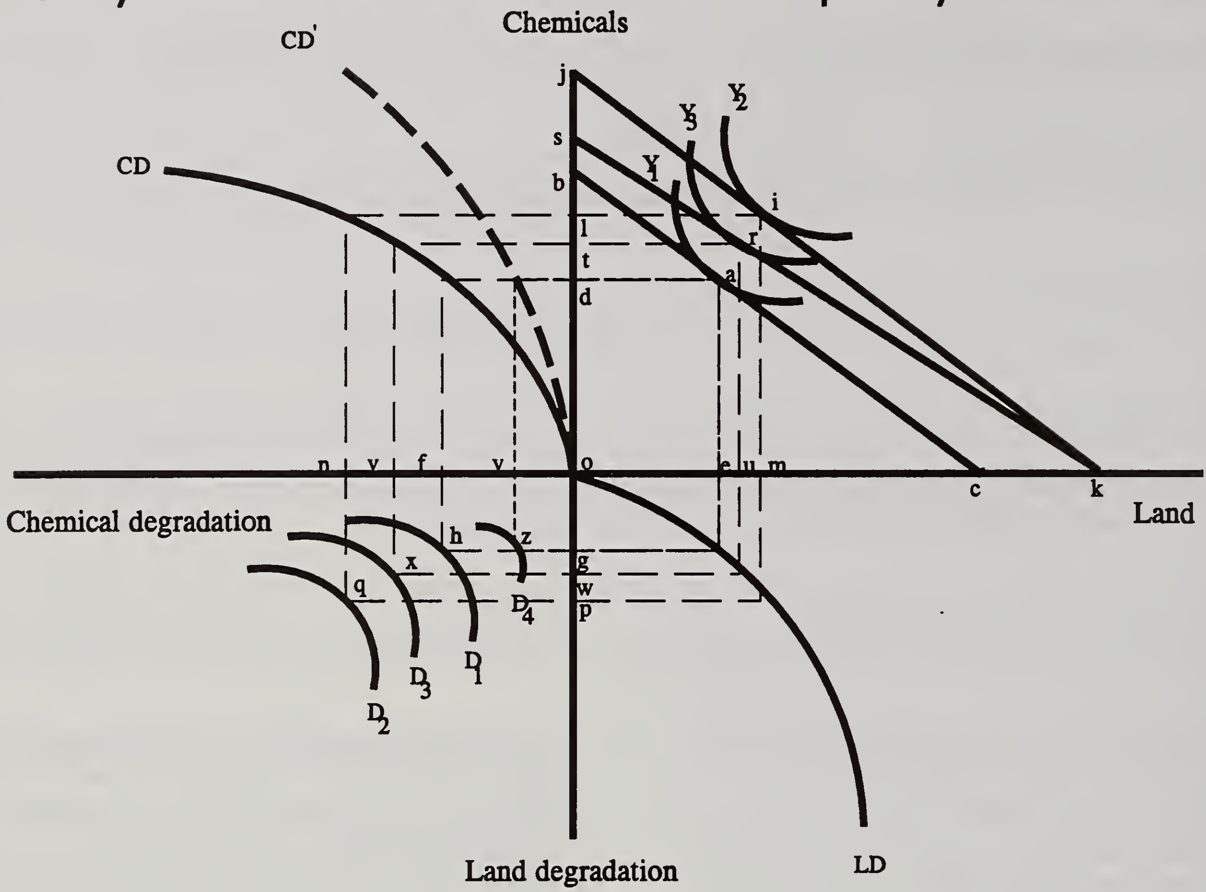
Within the context of agricultural trade policy reform, the most important characteristic of a policy is the degree to which it distorts trade. In agriculture, trade distortions arise from both domestic and trade policies. Indeed, a common problem in agriculture is the use of a variety of trade and domestic policies to intervene in agricultural markets while "tariffs, the traditional GATT negotiating subjects, are relatively unimportant to agricultural trade" (Schwartz, Magiera, and Mervenne, 1988). Consequently, in the agricultural and natural resource sectors, it is often difficult to separate trade policy from domestic policy, as trade goals are often achieved through domestic policy instruments or domestic goals are achieved through trade instruments. Clarifying which policies and policy instruments are potentially trade-distorting and then calculating the extent of the distortion is an ongoing task.[7] In the context of the NAFTA and agriculture, trade reform will reduce or eliminate, either immediately or over a 5-, 10, or 15-year period, all tariffs and quantitative restrictions on all agricultural products traded between the United States and Mexico.

Just as the implementation of agricultural and trade policy creates a complex range of environmental consequences, reforming policy generates an equally complicated set of environmental responses. Figure 1 illustrates the complexity of these interactions by showing how production, input use, and environmental quality respond to changes in output and input prices. The upper right-hand quadrant shows the relationship between inputs and output. Each of the output curves, labeled **Y**, shows the various combinations of inputs required to produce a given quantity of output. Output remains constant along

[7]There are several commonly used measures of the economic effects of government policies; all measures have advantages and disadvantages. The producer subsidy equivalent (PSE) estimates the effect of government policy by measuring the amount of cash subsidy or tax needed to hold farmers' income at current levels if all government programs were removed. The PSE has become the dominant empirical measure of policy impacts in agriculture (Masters, 1993). Other measures include the nominal protection coefficient, which measures the effect of government policies on market prices, and the effective protection coefficient, which measures the impact of policies on both output and input prices (see Masters for a discussion on measuring protection in agricultural markets).

Figure 1

Policy reforms and environmental quality



each output curve and output curves farther from the origin represent greater output. The shape of an output curve depends on the degree to which one input can substitute for another.

Prior to any change in agricultural policy, production is defined by the output curve, Y_1, with land use **oe** and chemical use **od.** This level of output and input use is congruent with relative input prices **bc**. **CD** in the upper left hand quadrant defines the relationship between chemical use and chemical-based degradation (pesticide contamination, fertilizer runoff); **LD** in the lower right hand quadrant defines the positive relationship between land use and land-based environmental degradation (such as deforestation or soil erosion). At the initial input levels, chemical degradation is **of**, and land degradation is **og.** Total degradation, which is mapped in the lower left-hand quadrant, shows the various combinations of chemical and land degradation. Like the output curves, total degradation is constant along any of the degradation tradeoff curves, **D.** At output level Y_1, total degradation occurs at **h**, on the degradation tradeoff curve D_1.

An expansion in output, due to an increase in producer prices or an increase in market access, can be illustrated by a shift in the production function to Y_2. At the higher level of output, land use increases to **om** and chemical use increases to **ol**; these levels are congruent with relative input prices **jk** (which, in this example are unchanged by trade reform). Note that the increase in chemical use is greater than the increase in land use. Chemical degradation increases to **on**, and land degradation increases to **op**. When combined, total degradation increases to D_2. In this example, output price reform leads to increased production, increased chemical and land degradation, and increased total degradation.

In Mexico, policy reform has also been directed at lowering input subsidies. Reducing a chemical subsidy (such as the fertilizer subsidy) raises the price of chemicals relative to the price of land (land is held fixed in this example). Higher chemical prices are represented by a shift in the input price line to **sk**. As chemical prices increase relative to land prices, the relatively higher price of chemicals lowers output to Y_3 and reduces chemical use to **ot**

and land use to **ou**. Total degradation occurs at **x**, on $\mathbf{D_3}$, which is a greater level than under the initial equilibrium, but less than when only output prices are reformed.

In the longer run, the relationship between chemical use and degradation can be altered through technological change in agricultural production (resulting in less intensive production methods) or through technological change in chemicals (resulting in less polluting chemicals). The latter is illustrated by **CD** shifting to **CD′**, where **CD′** is a new chemical degradation curve that represents less chemical degradation per unit of chemical uses. Although total chemical use remains unchanged, the amount of chemical degradation declines to **y** and total degradation declines to **z** on the $\mathbf{D_4}$ degradation curve.[8]

Mexican Agricultural Production and Environmental Quality

Structurally, Mexican agriculture has two distinguishing features that are environmentally important. First, Mexico has a bimodal production structure that consists of a small (in number) commercial sector producing grains, cotton, and fruits and vegetables in the Northern and Western States, primarily for export, and a large subsistence sector producing mostly maize and dried beans for onfarm consumption and domestic markets. The commercial sector generally has more access to credit, modern seed varieties, irrigation, and agricultural chemicals than does the subsistence sector, which relies on traditional production methods. Consequently, the commercial sector is likely to contribute more to environmental degradation that is associated with input-intensive production methods. At the same time, the traditional sector has less access to modern inputs and modern production methods, and these farmers are frequently farming the poorest quality land, with attendant soil fertility and erosion.

Second, Mexico has a well-established land tenure system which consists of: 1) private property owners; and 2) producers who do not own land but instead belong to public sector production cooperatives known as *ejidos*. In the early 1980's, the average private farm was 68 hectares, while the average ejido farm was 32 hectares (Food and Agriculture Organization (FAO), 1988). Estimates indicate that ejidos control approximately 60 percent of all agricultural land and over 55 percent of all irrigated land (Cook and coauthors, 1989). Although there are some exceptions, farm size, land rentals, and sales were restricted by law for many years, which limited expansion and production efficiency, and likely contributed to increases in labor and chemical use as farmers substituted labor and chemicals for land to increase output.

Mexico has a total land base of base of 190 million hectares, but only 12 percent is considered arable. Total arable area, which excludes pasture, has remained relatively stable at 23 million hectares since 1961 (FAO, 1989). Recent estimates indicate that about 25 percent of vegetated land is already moderately to extremely degraded, with much of the degradation attributable to erosion, deforestation, overgrazing, and agricultural practices (World Resources Institute, 1992). Rainfed dryland, which represents about one-half of total cropland in Mexico, is subject to severe land degradation, generally attributable to poor soils and steep terrain. Estimates indicate that the majority of crops planted on rainfed land are located on soils with a high risk of soil erosion (FAO, 1988). In the late 1980's, irrigated land, about 21 percent of total arable land, was vulnerable to depletion of ground and surface water supplies, increased water and soil salinity, and increased nitrate, phosphate, and pesticide contamination (FAO, 1989).

Between 1967 to 1969, and 1987 to 1989, total area devoted to grain production increased 3 percent with wheat, maize, and sorghum accounting for about 95 percent of total cereal production (table 1). During the same period, wheat area increased 26 percent, sorghum area increased over 100 percent, fruit and vegetable area increased over 78 percent, but area devoted to such staple crops as maize and beans actually declined 12 percent and 6 percent, respectively. Between 1967 to 1969 and 1987 to 1989, wheat yields increased over 51 percent, maize yields increased 44 percent, sorghum yields increased 26 percent, but dried bean yields actually declined by about 2 percent. Due to high yield increases, total wheat production increased over 90 percent during the 20-year period, but maize production, which exhibited a decline in area harvested and a relatively lower yield growth, only increased 27 percent. Due to increased area and yield, sorghum

[8]These longer run changes in technology are unlikely to be directly attributable to NAFTA but would more likely result from changes in domestic policy and increased per capital income, which may be indirectly attributable to more open trade.

Table 1—Mexican crop production: Area, yield, and production

	Total cereal	Wheat	Maize	Sorghum	Soybeans	Beans	Vegetables and fruit
Area				*1000 hectares*			
Average year:							
67-69	9,513	803	7,464	795	122	1,792	561
77-79	9,246	684	6,747	1,325	304	1,421	878
87-89	9,863	1,015	6,592	1,726	367	1,682	1,001
				Percent			
Change:							
60s-70s	-2.8	-14.8	-9.6	66.6	148.9	-20.7	56.4
70s-80s	6.7	48.3	-2.3	30.2	20.7	18.4	14.0
60s-80s	3.7	26.3	-11.7	117.0	200.5	-6.1	78.3
Yield				*Kilograms/hectare*			
Average year:							
67-69	1,431	2,708	1,165	2,609	1,900	.497	NA
77-79	1,902	3,681	1,464	3,162	1,683	.561	NA
87-89	2,224	4,102	1,676	3,282	1,804	.486	NA
				Percent			
Change:							
60s-70s	32.9	35.9	25.7	21.2	-11.4	12.8	-
70s-80s	16.9	11.4	14.5	3.8	7.2	-13.2	-
60s-80s	55.4	51.5	43.9	25.8	-5.1	-2.1	-
Production				*1,000 metric tons*			
Average year:							
67-69*	13,613	2,176	8,692	2,085	231	891	6,384
77-79	17,506	2,509	9,842	4,169	519	786	10,716
87-89	21,959	4,151	11,051	5,620	682	822	13,274
				Percent			
Change:							
60s-70s	28.6	15.3	13.2	99.9	124.7	-11.7	67.9
70s-80s	25.4	65.4	12.3	34.8	31.4	4.6	23.9
60s-80s	61.3	90.7	27.1	169.5	195.2	-7.7	107.9

*Three-year averages are reported to smooth out effects of unusual years.
Source: Food and Agriculture Organization. FAO Production Yearbook.

production grew almost 170 percent. Production of fruits and vegetables increased about 108 percent. Again, due to declines in both bean area and yield, total bean production declined about 8 percent.

As in crop production, the livestock sector consists of a export- oriented sector, located in the Northern States, and a traditional, grazing sector that serves the domestic market (Rosson and coauthors, 1993). Beef and veal production increased from 517,000 metric tons in 1967-69 to 1,777,000 metric tons in 1987-89, an increase of over 200 percent. Poultry production exhibited an increase of over 250 percent during the same period.

The data show a significant increase in the production of fruit and vegetables and sorghum and either an actual decline or slower growth in maize and dried bean production.[9] As discussed in the following sections, a significant portion of the wheat, sorghum, and fruits and vegetables are cultivated under irrigation, mechanization, and the use of agricultural chemicals, all of which can contribute to increased stress on soil, water, and forestland. Livestock production, particularly the

[9]Fruits and vegetables account for a large share of exports to the United States. For example, in 1990 fruits and vegetables accounted for about 56 percent of the total value of Mexican agricultural exports to the United States (Hufbauer and Schott, 1992).

Table 2—Mexican cattle stocks and cattle densities, by region, 1972 and 1987

Region	1972 Cattle stocks	1972 Regional share	1987 Cattle stocks	1987 Regional share	Change 1972-87	Area	Head per hectare 1972	Head per hectare 1989
	Head	*Percent*	*Head*	*Percent*	*Percent*	*1,000 hectares*	*------Head------*	
Northwest	3,400,370	12	4,577,105	13	34.61	41,444	.082	.110
North	4,519,492	16	4,627,656	13	2.39	51,831	.087	.089
Northeast	1,820,527	6	1,852,950	5	1.78	14,438	.126	.128
North Center	1,878,930	7	2,358,433	6	25.52	14,348	.131	.164
West Center	5,594,083	20	8,284,013	23	48.09	25,161	.222	.329
Center	2,607,990	9	2,841,622	8	8.96	8,672	.301	.328
Gulf South	7,425,841	26	10,481,426	29	41.15	26,673	.278	.393
Peninsula	987,491	3	1,553,469	4	57.31	14,153	.070	.110
Total	28,234,724	100	36,576,674	100	29.55	196,719	.144	.186

Sources: Base de Datos Pecuaria. Subsecretaria de Planeacion, Direccion General de Estudios, Informacion y Estadistica Sectorial, SARH, November, 1989 (provided by C. Parr Rosson, Texas A&M University).

feed cattle system in the north, is "strained by overgrazing" (Rosson and coauthors, 1993), while livestock production in the south has contributed to deforestation. In addition, as maize and bean land are converted to commercial-crop production, the highest quality land is likely converted first, leaving more marginal land in traditional-crop production, which may contribute to poorer yield performance, and environmental stress.

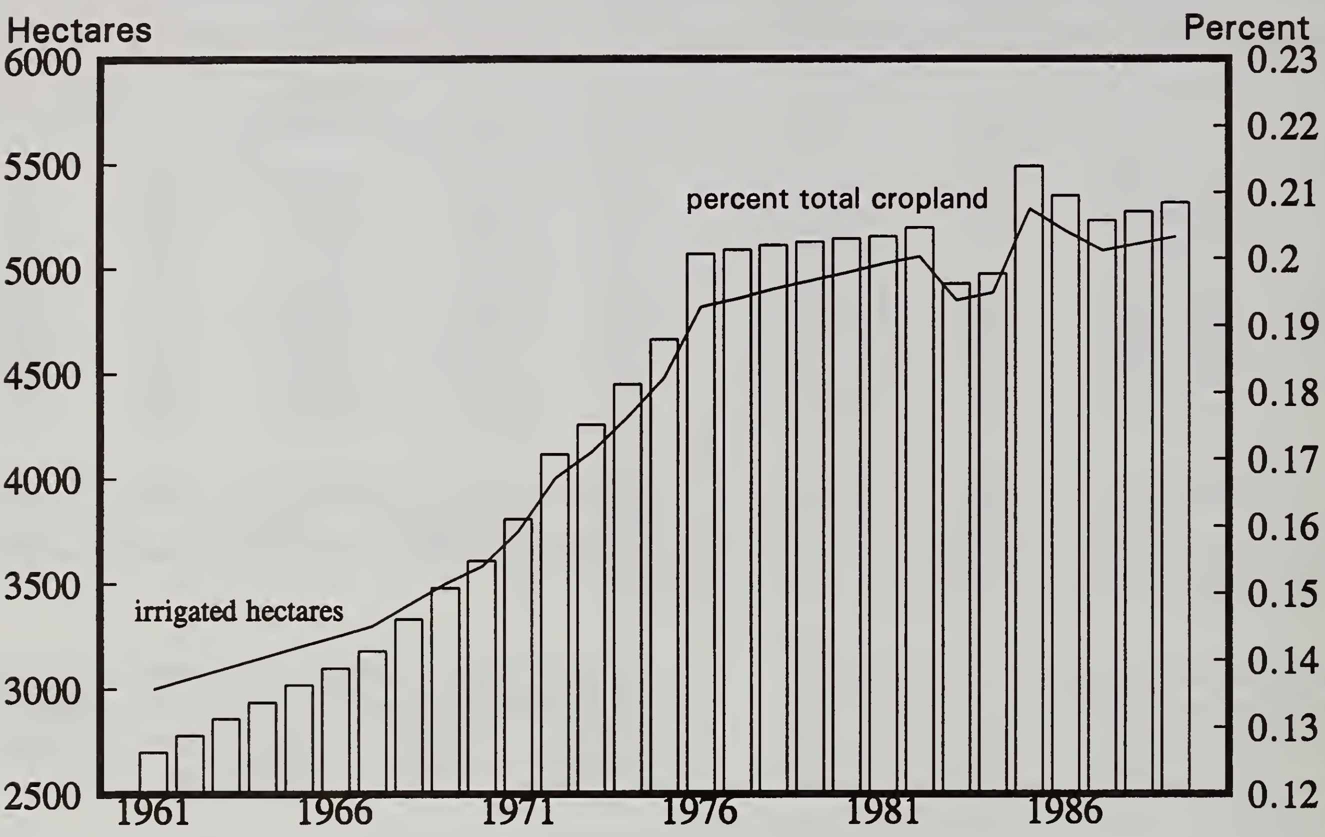
Deforestation in Mexico: Causes and Effects

Deforestation, which is often caused by converting forestland into agricultural land, contributes to land degradation through the loss of soil nutrients, to climate change through the release of carbon into the atmosphere, to a decline in biodiversity, and to degradation associated with crop cultivation and livestock production on converted land.

Currently, Mexico's forest resources cover 142 million hectares (about 73 percent of total area). Dense forestland covers about 39 million hectares; 70 percent of which is temperate forest in the Sierra Madre Occidental mountain range extending from the U.S. border to southern Mexico. The remaining dense forestland is tropical hardwood forest, located mostly in the Gulf South States. About 84 million hectares are semiarid shrubs and brushlands and over 18 million hectares are deforested area. The FAO estimates that, since 1967, Mexico's densely forested area has declined by 15.5 million hectares, or 27 percent. According to FAO data, during the early and mid-1980's, Mexico's average rate of deforestation exceeded the average rate for all tropical countries.

Deforestation is generally attributed to three causes: increased demand (typically foreign) for tropical woods, increased demand for domestic firewood, and cattle raising. In Mexico, tropical deforestation is primarily associated with conversion for cattle raising. While timber production is important in Mexico, timber products typically come from temperate forests that regenerate naturally. Deforestation has been particularly acute in the tropical forests in the Gulf South and Peninsula regions. Federally supported clearing programs have provided incentives to expand the agricultural frontier by converting forestland to agriculture. Because Mexico's land tenure system has, in the past, effectively prevented large-scale, modern ranching operations, cattle production has been typically land-extensive (recently, there has been growth in confined feeding operations in northern Mexico). Although cattle/land densities have increased in most regions since the early 1970's, the Gulf South and Peninsula regions, where extensive deforestation has occurred, have experienced significant increases in cattle stocks (table 2). As forests are converted to pastureland for cattle, several negative environmental consequences, such as increased soil erosion, disruptions of the hydrologic cycle, and a loss of plant and animal species can occur (World Bank, 1992).

Figure 2
Irrigated areas and percent of total cropland, 1961-89



Irrigation

The growth in irrigated agriculture in Mexico has been an important factor in the increase in Mexican agricultural productivity and has contributed significantly to Mexico's ability to compete in export markets. Since 1961 total irrigated area has increased from less than 3 million to more than 5 million hectares (a 72-percent increase), with an average annual 2 percent growth rate in irrigated area (fig. 2). Irrigated area, as a percentage of total arable area, increased from 13 percent in 1961 to 21 percent in 1989 (fig. 2). Growth in irrigated area between 1961 and 1970 was 19.4 percent, while growth between 1971 and 1980 was 32.8 percent. However, between 1981 and 1989, irrigated area increased only 2.6 percent.

This slowdown is attributed to several factors, including: (1) increased marginal costs of irrigation projects, (2) increased interest rates, (3) decreased foreign loans (a major source of irrigation funding), (4) budgetary restraint that curbed irrigation expansion, (5) increased energy costs, and (6) price declines for irrigated commodities. The future of Mexican irrigated agriculture may be threatened in some areas because, given the current overdraft of aquifers, increased pumping of groundwater cannot be sustained in the long run, and excessive salinity in irrigation water may render agricultural lands useless over time (Wilson and Thompson, 1992).

Due to Mexico's climate, irrigation is required for a significant share of total crop production. For example, in 1990-91 about 68 percent of all wheat area was irrigated, compared with 11 percent of maize area (table 3). Water availability is particularly crucial in the arid Northwest. In Sonora, more than 70 percent of arable land is irrigated, water demand is depleting groundwater supplies, and competition from the United States over water use is further eroding the regions' water supply (Liverman, 1990). But irrigation is not restricted to arid and semiarid zones and is also required to supplement rainfall in subhumid or humid zones during the dry season. For example, about 50 percent of total maize area is located in

Table 3—Irrigated area by region and selected crops, 1990-91

Region	Maize			Wheat		
	Total area	Regional share	Area irrigated	Total area	Regional share	Area irrigated
	1,000 hectares	----------*Percent*----------		*1,000 hectares*	----------*Percent*----------	
Northwest	216	3	39	483	49	100
North	508	7	16	313	32	9
Northeast	54	1	69	55	6	45
North Center	594	8	9	0	0	100
West Center	2,268	31	14	124	13	100
Center	1,755	24	13	4	<1	35
Gulf South	1,552	21	0	2	<1	100
Peninsula	292	4	2	0	0	0
Total	7,239	100	11	981	100	68

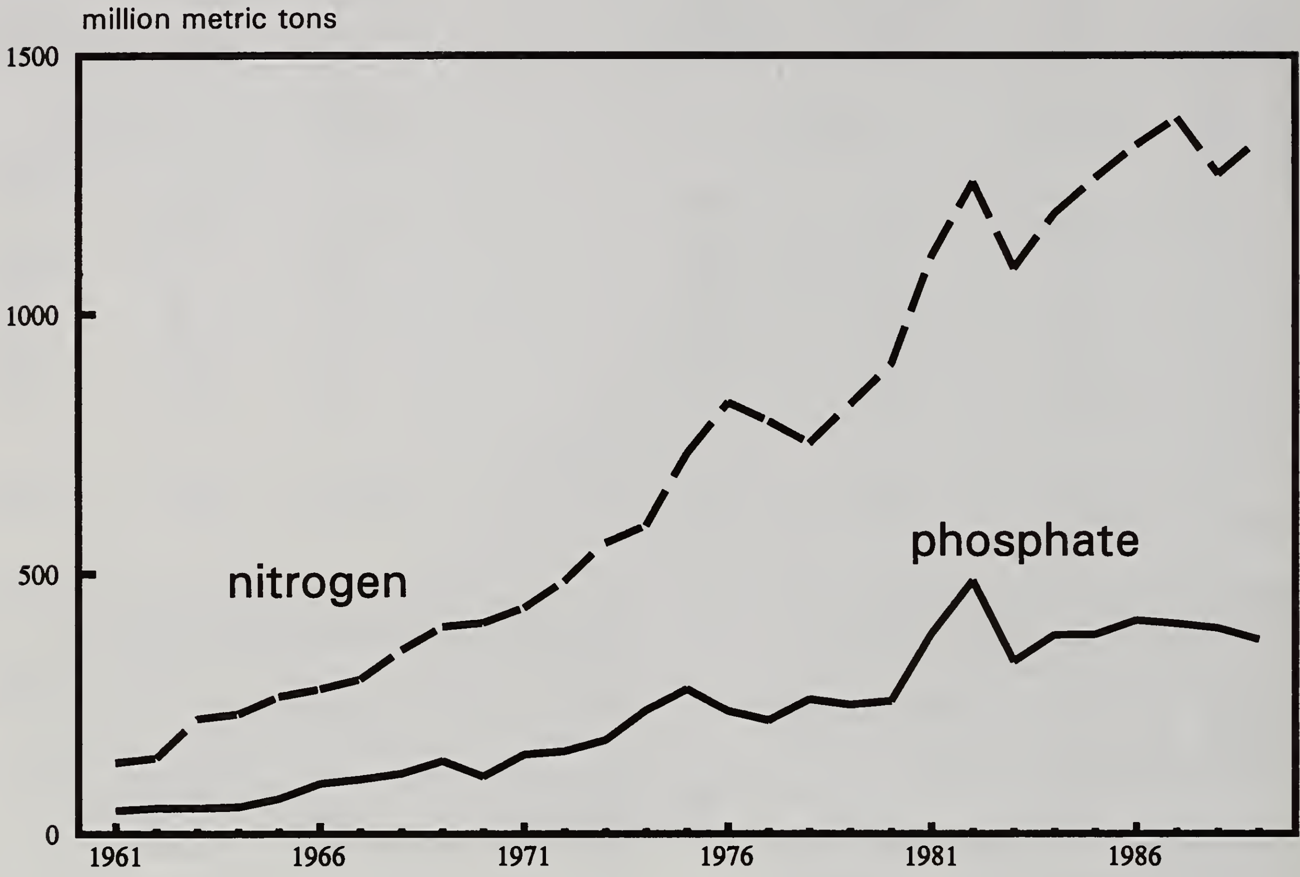
the less arid West Center and Center Regions, and about 14 percent of this maize area is irrigated (table 3). Many fruits and vegetables are produced in less arid regions, and frequently, their growers receive precedence over grain and bean producers in the allocation of water (Mares, 1987).

Until recently, irrigation construction, maintenance, and user fees have been substantially subsidized by the Mexican Government. Like many countries, Mexico implemented irrigation subsidies to achieve several goals such as increasing agricultural production, attaining agricultural self-sufficiency, keeping food prices low in urban areas, and improving international competitiveness. Although irrigation subsidies have varied by crop, it is estimated that, in recent years, producers have paid about 30 percent of the market price for irrigated water and about 50 percent of the operation and maintenance costs[10]. It is well known that subsidizing irrigation projects and water use acts as a disincentive to the efficient use of irrigation water, which can increase the external diseconomies associated with irrigated agriculture, such as water logging. In June 1991, Mexico introduced a law to allow Government recovery of the capital cost of irrigation investments, which in principle could allow some sharing of investment costs with agricultural producers (Levy and Wijnbergen, 1991).

As in many countries, irrigation is only one part of a technological package that includes modern seed varieties and the use of agricultural chemicals. Consequently, in addition to depleting ground and surface water supplies, irrigation can result in water and soil salinity and in increased nitrate, phosphate, and pesticide contamination. Salinization, which can occur naturally, also results when dissolved salts in irrigation water remain in the soil as water evaporation occurs. Estimates indicate that salinity levels in excess of 500 milligrams per liter can reduce agricultural productivity, as well as damage the irrigation equipment (Gardner and Young, 1988). Salinity can be detrimental to yields of such salt-intolerant commodities as onions and tomatoes, while other crops, such as wheat and soybeans, are less sensitive to salinity. In 1980, it was estimated that 12.4 percent of Mexican irrigated area was either wholly or partially affected by salinization, with the greatest degree of damage occurring in the arid and semiarid north (FAO, 1988). To control salinization, drainage systems can be installed to collect salted water, which is then blended with fresh water and either discharged or evaporated. While draining saline water is beneficial to farmers within the drainage system, it can produce an externality for other farmers. It is too early to assess any environmental benefits associated with the apparent leveling off in the growth in irrigated area, but because water use has been priced well below its marginal cost, moving toward market orientation by removing subsidies could help reduce environmental degradation.

[10]Constanza Valdes, personal communication, Economic Research Service, U.S. Department of Agriculture.

Figure 3
Total fertilizer use in Mexico, 1961-89



Agricultural Chemical Use

Along with irrigation, fertilizer use also increased significantly in Mexican agriculture. Between 1961 and 1989, per hectare nitrogen and phosphate fertilizer use in Mexico increased 800 percent and 600 percent, respectively (fig. 3). Estimates indicate that, like other modern inputs, fertilizer use is particularly high in regions producing wheat, sorghum, and fruits and vegetables. For example, nitrogen use per hectare of wheat is highest in irrigated areas in the North and Northwest (table 4). In general, nitrogen fertilizer use is higher on irrigated maize and sorghum than on nonirrigated crops. For example, per hectare nitrogen use on irrigated maize averages 112 kg/ha, while per hectare nitrogen use on nonirrigated maize averages 73 kg/ha.

In Mexico, increased fertilizer use is partially attributed to fertilizer subsidies, which have been prominent in Mexican agricultural policy. Although Mexican fertilizer subsidies have declined in recent years, these often resulted in fertilizer being priced well below world market prices. The apparent decline in the rate of increase in fertilizer use since 1981 is attributable to significant changes in output prices and to reductions in fertilizer subsidies. For example, in 1985, fertilizer subsidies resulted in Mexican fertilizer prices being about 69 percent below world prices; by 1989 they fell to about 55 percent below world prices (prices are weighted averages of nitrogen, phosphate, and potash) (FAO, 1990).

Although there are limited data on the extent of groundwater contamination in Mexico, in other agricultural production regions, leaching of nitrogen fertilizer is generally considered the primary source of nitrate contamination of groundwater (Hanley, 1991). Fertilizer subsidies and price supports can encourage the inefficient use of fertilizers, and lead to offsite water quality problems if unused nitrogen and phosphorus leach through the soil into water supplies. Irrigation can exacerbate nitrate leaching as repeated applications of water increase the movement of fertilizers and other chemicals through the soil. Nitrate exposure can have adverse consequences for human health and can damage the physical environment through

Table 4—Nitrogen fertilizer use, by region and selected crops, 1990-91

Region	Maize		Wheat	
	Irrigated	Not irrigated	Irrigated	Not irrigated
	Kilograms/hectare			
Northwest	213	84	203	-
North	150	50	113	68
Northeast	104	81	151	100
North Center	110	46	110	-
West Center	88	78	207	-
Center	97	77	98	100
Gulf South	-	73	90	-
Peninsula	40	29	-	-
Total	112	84	198	60

eutrophication. It is important to recognize that nitrates can take up to 40 years to travel from the soil to groundwater (Hanley, 1991); consequently, the adverse effects of fertilizer use may not materialize until well into the future.

Along with fertilizers, pesticide use has also increased in Mexican agriculture, although detailed data on regional pesticide use by crop is not available. While often considered essential for high yields and appearance, pesticides can contaminate water supplies, kill beneficial predators, destroy wildlife, and present health risks for farmers and consumers. The FAO reports that between 1975 to 1977, and 1982 to 1984, aggregate pesticide use in Mexico has increased from 21,063 tons to 30,393 tons (of active ingredient), a 44-percent increase (FAO, 1989). As in the case of other variable inputs, some of the increase in pesticide use can be attributed to subsidies that reduce the cost of chemicals to farmers.

Freer Trade and Environmental Quality in Mexican Agriculture

Although it is impossible to ascertain precise agricultural environmental impacts of freer trade in Mexico, several conclusions can be inferred from estimated NAFTA-induced changes in agricultural production and recent resource and production patterns. In the past, Mexico has supported agriculture through a complex program of producer and processor subsidies, consumer subsidies, input subsidies (credit, chemicals, irrigation), and import licenses and tariffs. Since the early 1980's, Mexico has reduced trade barriers and domestic support. For example, between 1982 and 1990, the overall average tariff level fell from 27 percent to 13 percent; by 1990, the average tariff on agricultural products fell to 4 percent (Meilke, von Massow, and van Duren, 1991). Among other provisions, NAFTA calls for the immediate elimination of import tariffs on agricultural products with low or negligible duties and gradual reduction of remaining tariffs. The schedule varies from 5 to 15 years, across products.

Preliminary estimates indicate that NAFTA will lower Mexico's production of corn and grains (wheat, sorghum) and soybeans (Krissoff, Neff, and Sharples, 1991) and increase the production of some fruits and vegetables. Reducing U.S. tariffs on fruits and vegetables will result in moderate price increases for Mexican producers and increased Mexican production of melons, cucumbers, and tomatoes. Slight declines in Mexican beef production are estimated, along with increased production of poultry and pork and increased cattle stocks. For example Krissoff, Neff, and Sharples (1991) estimate these gains and losses in production: maize declines 7.3 percent; coarse grains decline 10.9 percent; cattle stocks increase 0.2 percent; beef decreases 0.2 percent; pork increases 0.5; poultry increases 2.1; eggs increase 2.5 percent; melons increase 2.4 percent; frozen orange juice increases 18.6 percent; cucumbers increase 6.6 percent; onions increase 3.8 percent; green peppers increase 1.6 percent; and tomatoes increase 1.6 percent.

Lower grain output will cause some grain areas to come out of production, but the increase in fruit and vegetable production will, at least in the short run, be concentrated in those areas already producing for the U.S. market, either by bringing additional land into production or increasing the intensity of cultivation. Consequently, environmental problems associated with fruit and vegetable production, such as chemical use and irrigation, will likely continue.[11] And although fruit and vegetable production increases, production of other chemical-intensive commodities, such as wheat and sorghum, declines, so that the net effect of NAFTA on total pesticide use is not

[11]Corrective action to encourage alternative, less intensive, agricultural practices is always an option to reduce environmental damage. On the positive side, Mexico is concurrently reducing subsidies for water and chemicals, which can lower the rate of environmental degradation associated with irrigation, pesticides, and fertilizer.

significant. While total use may not change, what is important from an environmental perspective is the intensity of chemical use in geographic areas vulnerable to chemical leaching. At this time, there is not enough data to identify the vulnerable areas in Mexico.

Mexican livestock production under NAFTA is estimated to respond positively to lower imported feed prices and to increased access to the U.S. market, which could encourage Mexican cattle (cow/calf) operations in the Northern States and along the border. Because these operations rely on pasture for feed, wheat and sorghum area will potentially be converted to pasture. If input intensive crop area is replaced with properly managed pastureland, environmental gains can result as pastureland is relatively less environmentally degrading (Reichelderfer, 1985).

The impact of NAFTA on the rate of deforestation depends on several factors that include the shortrun effects of reduced tariff and nontariff barriers on timber, livestock, and related products. Similarly, reducing trade barriers in feed grains could alter the structure and regional production of livestock in Mexico. The rate of deforestation could also be affected by longer term factors that are indirectly related to NAFTA-induced freer trade. These factors include increased demand for animal products, which is associated with increased income and population growth. This increased demand would be partially supplied by imports, which could reduce pressure on Mexican forest resources. The likely adoption of confined livestock operations could decrease the rate of deforestation for pastureland, but increase the environmental consequences associated with confined livestock operations, such as the potential contamination of ground and surface water if manure and wastewater are not properly managed (OTA, 1990).[12]

Other agriculturally related environmental issues associated with freer trade include "pollution haven" arguments and the effect of freer trade on economic growth and environmental quality. A pollution haven describes the situation that occurs when countries with low environmental standards or lax enforcement encourage production of pollution intensive goods. This phenomenon is a trade issue because trade agreements, such as NAFTA, open up barriers to investment that can increase foreign investment in pollution-intensive industries. Also, countries with relatively lax standards can benefit from any competitive advantage created by the disparity in environmental standards.

But the decision to invest in or relocate to a foreign country is more likely to involve many factors in addition to the cost of meeting (or not meeting) environmental standards. These factors can include labor and capital costs, relocation costs, demand in the foreign market, and transportation costs associated with shipping goods back to domestic markets. In agricultural production, the quality and availability of land and water resources are also likely to play an important role in decision to relocate production.

Because the cost of meeting U.S. environmental regulations appears to be quite small for many industries, it is unlikely that firms will decide to relocate on the basis of avoiding them. For example, Low (1992) estimates that the average 1988 cost of pollution abatement for all U.S. industrial production was less than 1 percent of the value of industrial output. The highest cost of pollution abatement occurred in petroleum refining (about 4 percent of the value of output). The fruit and vegetable processing industry incurred costs of less than 1 percent of the value of production, while the cost to the agricultural chemicals industry was about 2 percent of the total value of output (estimates were not computed for farm-level agricultural production).

For agricultural production, particularly in the food processing sectors, relocation is more likely to depend on lower labor costs.[13] For example, in recent years U.S. poultry processing and fruit processing firms have relocated to Mexico to take advantage of lower labor costs as well as to produce for the Mexican market. Under NAFTA, potential exists for significant growth in such processed products as canned and frozen fruits and vegetables, with an increase in pollution associated with processing. An added benefit to these firms may be in the lower water quality

[12]NAFTA will reduce Mexican maize prices, thus reducing maize production, which is concentrated on small farms in rainfed areas that, in many cases, are on marginal land. Environmental gains, such as reductions in soil erosion, could occur if portions of this land came out of production, but at the same time, there could be offsetting adverse economic effects if these farmers are forced to move to already congested urban areas.

[13]This is not only true for the agricultural sector. Several studies indicate that environmental considerations are a negligible factor in the decision for U.S. companies to invest abroad.

standards in Mexico (resulting in less management of effluents), but it is unlikely to be the most important factor in the decision to produce in Mexico.

According to a U.S. International Trade Commission Report, U.S. investment in the Mexican food processing industry fell 17 percent annually during 1983-88, but rebounded 81 percent in 1989 to $466 million (USITC, 1991). The turnaround is partly due to recent changes made by Mexico in foreign investment rules. The Mexican food processing sector has been growing at an annual average rate of 20 percent (relative to a 5-percent growth rate for exports of fresh products). NAFTA may encourage an increase in investment in more labor-intensive industries, like food processing, but factors other than labor costs are important and these factors can be processor-specific.[14]

The second version of the pollution haven argument holds that pollution-intensive industries are concentrated in developing countries, caused not by multinational relocation, but by countries maximizing their comparative advantage in "dirty" industrial production (a dirty industry is defined as one incurring high levels of pollution abatement and control expenditures). Low and Yeats (1992) examine whether poor countries specialize in the production of dirty goods, and they find that some developing countries producing dirty goods enjoy a comparative advantage, and that these industries account for a growing share of their exports. Although their study does not examine the causes of this concentration, the authors argue that it can be attributed to several factors, including lower costs of production, technological factors, differences in income, and early stages of industrialization, but that concentration in dirty production is not likely due to environmentally motivated investment decisions. It is to be noted that this study draws no conclusions regarding trade openness and dirty production, nor does it attempt to analyze the government support to dirty industries and the implications for reduced support due to trade reform.

It is widely recognized that trade reform can be a positive catalyst for economic growth, but the environmental effects of growth are not always readily apparent. Some argue that increased production necessarily accompanies economic growth, which leads to an increase in environmental degradation associated with additional output. However, economic growth can also change a country's output and input mix, resulting in a more efficient use of resources. Additionally, economic growth can be accompanied by an increase in the demand for newer, cleaner technologies and an increase in the demand for environmental quality.

Even if growth leads to an increase in polluting production in the short run, there may be several ameliorating factors that improve environmental quality over time. The costs associated with increased environmental pollution (such as an increase in nitrates in groundwater or an increase in soil erosion due increased agricultural production) may be less than the benefits associated with economic growth (such as higher per capita income, greater production efficiency, and a more stable macroeconomy). For some economies, an increase in pollution is only temporary and is reduced as further growth occurs. This is generally thought to be the case for air pollution and pollution with no stock feedback effects, which can frequently be controlled through the use of more modern technologies that are acquired as income increases.[15] This may not be the case in industries that rely on resource stocks (forests, soil depth, water). An increase in production caused by economic growth can deplete or seriously affect the quality or quantity of a resource stock, often beyond its regenerative ability or beyond its assimilative capacity.

The view that open trade increases economic growth, which in turn increases the demand for environmental quality, is commonly used to justify positive environmental effects of free trade. While there is empirical evidence that higher per capita income is positively correlated with a greater demand for environmental quality, these estimates are based on correlations between income and ambient emissions, the correlation between income and resource degradation (that is, deforestation, loss of soil nutrients, loss of water quality) is less clear and less quantifiable. It is precisely these

[14]For example, in the United States, environmental costs of fruit and vegetable processing are estimated at less than .1 percent of sales for firms that are not large users of process water; for firms that use large quantities of process water, environmental costs may exceed 1 percent of sales (Kirk, 1985).

[15]Stock feedback effects occur when the quality or quantity of a resource is affected by production. For example, agricultural production can result in soil erosion; soil resources are depleted, thus affecting future production.

studies that produce the inverted U-curve, a shape describing the relationship between per-capita income and environmental spending: at low income levels countries spend relatively little on improving environmental quality, but as income increases, more expenditure occurs. Estimates indicate that the demand for environmental quality becomes important at income levels of about $5,000 per capita (Grossman and Krueger, 1991). Many high-income countries have already experienced improvements in air quality and increases in forested area and protected habitats (World Bank, 1992). This argument is further developed by Antle and Trigo (1992). Their environmental transition hypothesis states: "Economic growth is likely to be accompanied by environmental degradation at low-income levels but as income increases, the demand for environmental protection may bring about a path characterized by both economic growth and environmental improvement."

Conclusions

It is unlikely that freer North American trade will significantly improve or worsen the quality of Mexico's agricultural environment beyond what would be expected without trade reform. While some agricultural subsectors in Mexico, such as fruits and vegetables, are expected to grow more rapidly and potentially contribute to increased environmental degradation, the reduction in input subsidies and irrigation credits will tend to ameliorate any negative effects of increased production. Increases in livestock production induced by freer trade are not likely to contribute to deforestation, primarily because the increases would be small and because land already under grain production could be substituted for livestock production, resulting in no net increase in deforestation attributable to NAFTA.

Free trade can increase economic growth, which can affect environmental quality. Higher GDP can increase the demand for fruits and vegetables and livestock products, which are associated with environmental degradation. But income growth can have a positive environmental impact as higher GDP leads to increases in the demand for environmental quality. For example, although Mexico has not fully developed a system to implement environmental goals, funding for its environmental agency, SEDUE, has been steadily increasing in recent years.

It is important to recognize that, even though NAFTA is not expected to significantly increase or decrease the rate or degree of environmental degradation in Mexico, environmental issues will require attention. Mexico, like other countries, rich and poor, will face food safety and environmental problems with or without free trade. As Dean points out,

> " ...trade liberalization ... will undoubtedly have some impact on the use of natural resources and the extent of environmental degradation. However, the type of impact is not predictable a priori. Second, even if one were able to predict that certain trade reforms would increase the export of, say, a natural resource, this would not imply that reform should not be made. The problems of optimal resource use and optimal rate of degradation lie in appropriately determining the shadow prices of resources and internalizing externalities. These are domestic problems. Although certain trade polices may help achieve such a domestic objective,they are, at best, second-best methods of doing so (Dean, 1992).

Controlling or containing agricultural environmental pollution, encouraging efficient resource use, and slowing the rate of deforestation will likely require several policy approaches, including both economic and regulatory instruments.

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Chapter 9

Coordination of Agricultural Trade and Environmental Policy: A Western Hemisphere Example

Nicole Ballenger, Rachel Beattie, and Barry Krissoff

This chapter explores potential trade agreements in the Western Hemisphere, using a conceptual model and an empirical case study. In the conceptual model, regional trade agreements set the stage for a bargain between groups in the "North" representing environmental interests, and groups in the "South" representing trade expansion interests. The case study considers a preferential trade agreement for a single commodity and the regulation of an environmental externality, such as a pesticide, associated with the production of that good.

Introduction

Trade negotiations have provoked debate about the effects of free trade on environmental quality. Trade promotes economic growth, but some argue that expanded economic activity means degradation of the natural environment. They also suggest that enhanced economic activity will occur in the countries with the least stringent environmental policies. By contrast, others argue that as income increases, communities have more resources to spend on evironmental protection and on replacing outdated capital with possibly "cleaner" technologies; thus, freer trade may enhance environmental quality.

Even with increases in income, a country may not choose to adopt certain environmental measures, perhaps due to different social preferences or political objectives. A developing country's policy choice may, for example, be weighted more toward rapid economic growth and less toward environmental protection than the policy choice expressed in a developed country (Anderson, 1992a).

An opportunity for developed and developing countries to balance their differing preferences for economic expansion and environmental protection may be possible through trade agreements.[1] This paper presents a simple hypothetical example of such a balancing. A modeling experiment is used to compare the potential benefits for several Latin American countries of a free trade agreement with the United States and the potential costs to them of simultaneously adopting stricter environmental standards. The example is limited to a composite agricultural commodity (fruit juices), and a single environmental issue associated with the production of that commodity (farmworker exposure to pesticides).

To jump ahead, we conclude in this limited case study that the gains in export earnings to the Latin American countries from free trade in fruit juice outweigh the costs of stricter farmworker safety controls. Our example may provide a helpful framework for future analysis of environmental and trade policies for other agricultural commodities and other environmental externalities. In other examples, the costs of new environmental regulations may or may not exceed the benefits to the country enacting a free trade agreement.

A Simple Trade and Environment Model

The conceptual model explores a simple, hypothetical example of a trade and environment negotiation. We assume world trade in a single or composite agricultural commodity occurs among a large importer (C1), a small exporter (C2), and a large rest-of-world (ROW) net exporter.[2] While not necessary, C1 may be a developed country and C2 may be a developing country. The negotiations are over a preferential trade agreement between C1 and C2, whereby C1 would be willing to reduce the tariff applied to C2's goods if the agreement results in an improved level of environmental quality associated with the production of the good in the two countries (dEQ). Thus, as a part of the negotiations, C1 may ask C2 to impose new or

[1]The proposed North American Free Trade Agreement (NAFTA), for example, incorporates both trade-opening and environmental provisions. The environmental provisions call for the countries to work together to enhance the protections of human, animal and plant life and health.

[2]Although trade negotiations often focus on individual commodity issues, environmental policy analysis should take into account cross-commodity effects. This analysis could be expanded to a multicommodity framework.

stricter environmental standards.[3] We assume that C2 is mainly concerned with expanding its exports (dXR_2) as a means to promote economic growth, and is not as concerned with the environmental issue of interest to C1.

Possible outcomes of a trade and environmental policy negotiation can be located in the four-quadrant diagram, figure 1. Outcomes that fall in quadrant I are associated with an improvement in environmental quality and an increase in C2's export revenues; outcomes in quadrant III imply a deterioration in environmental quality and a decrease in the value of C2's exports. Those outcomes falling in quadrant IV are associated with an improvement in environmental quality and a decrease in C2's exports earnings, and, finally, those falling in quadrant II indicate a deterioration of environmental quality and an increase in C2's export earnings.

A free trade solution with no new environmental policy could occur at a point like c (in quadrant II) or d (in quadrant I), but not in quadrants III or IV. The reduction or removal of an import tariff by C1 would lower the price of imports originating from C2 and would encourage C1 consumers to increase their purchases from C2. C2's exports, therefore, would expand, eliminating quadrants III and IV as possible free-trade solutions.

At outcome d, free trade improves environmental quality, perhaps because it shifts production toward a less environmentally vulnerable region or toward a region employing a more environmentally friendly production technology.[4] By contrast, at outcome c, free trade raises export revenue for C2 but decreases environmental quality. This could happen because opening trade shifts production toward a more environmentally vulnerable region or to one with a lower environmental performance standard.

[3]For analytical convenience, the conceptual model assumes that any agreement would cause adjustments only in C1 and C2, of such magnitude that a change in the price at which the good is traded is due only to the actions of C1. In other words, in addition to C2 being "small," export supply of ROW is assumed to be perfectly inelastic. We relax these assumptions in the empirical model.

[4]Some regions are more vulnerable to environmental problems associated with agricultural activities than other regions. For example, other factors equal, a farming region with very steep slopes will be more prone to soil erosion than regions without steep slopes. Or, other factors equal, a region with highly leachable soils will be more vulnerable to water quality problems due to nitrate leaching than regions with less leachable soils.

If free trade results in a point like c, then in our hypothetical negotiation C1 will seek the imposition of an environmental policy in C2. A feasible, negotiated solution would have to fall in quadrant I, where both dXR_2 and dEQ are nonnegative. For any given tariff reduction by C1, there is a set of environmental policy options in C2 that would produce outcomes in quadrant I. For example, a large tariff reduction by C1 and a small environmental regulation in C2 could produce an outcome near point a where C2's gain in export revenue is large and the change in environmental quality is small. Alternatively, the same tariff reduction by C1 and a large environmental regulation in C2 could produce an outcome near point b, where C2's gain in export revenue has been eroded by the cost of taking on the environmental regulation while the effect on environmental quality has been large. Between the points a and b we can trace out the tradeoff frontier between dXR_2 and dEQ.

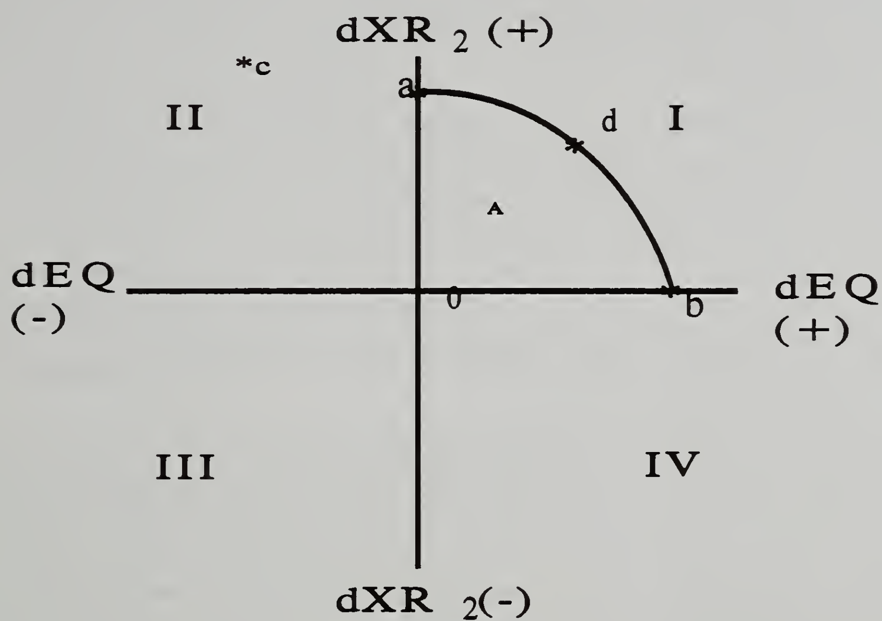
The effect of removing C1's tariff while imposing an environmental regulation in C2 are depicted for C2 in figure 2. The top panel is a diagram of supply and demand for the privately produced agricultural good. The bottom panel relates the production of the private good inversely to environmental quality along a transformation function TR. Each transformation function represents a unique production technology. Along each transformation schedule, the greater the production level (Q), the lower the environmental quality (EQ), but some production technologies are environmentally "friendlier" than others.

The removal of the tariff in C1 increases the price facing C2 from P^o to P^1, which expands C2's production from Q^o to Q^1. Because of the production change, and in the absence of a new environmental policy in C2, environmental quality declines along the frontier TR^o from point e to point f.

The imposition of an environmental control policy in C2 shifts the frontier representing the transformation between EQ and Q to TR^1. This occurs because of the assumption that an environmentally "friendlier" technology is adopted in response to the environmental control policy. Each level of output (Q) now has a less deleterious effect on EQ compared with the pre-environmental policy technology. However, because the new technology encompasses the cost of meeting the requirements of the environmental regulation, the policy raises producers' marginal cost of

Figure 1

Tradeoffs between environmental quality and export revenue



production, which shifts the supply function in the top panel to the left from S to S^1. Based on the higher cost but environmentally preferred technology, C2's production falls to Q^{11}, and EQ improves to point g on TR^1.

Point g could represent a feasible solution to the negotiation, that is, one at which environmental quality in both countries improves and C2's export revenues increase. At point g, C2's export revenues are positive, in relation to the prenegotiation level, if $(Q^{11}-D^1)P^1$ is greater than $(Q^o-D^o)P^o$. At point g, environmental quality is improved over the prenegotiation situation, if we assume that the decline in production of the good in C1--as C1's imports from C2 increase--has not adversely affected the environment.

An Empirical Example

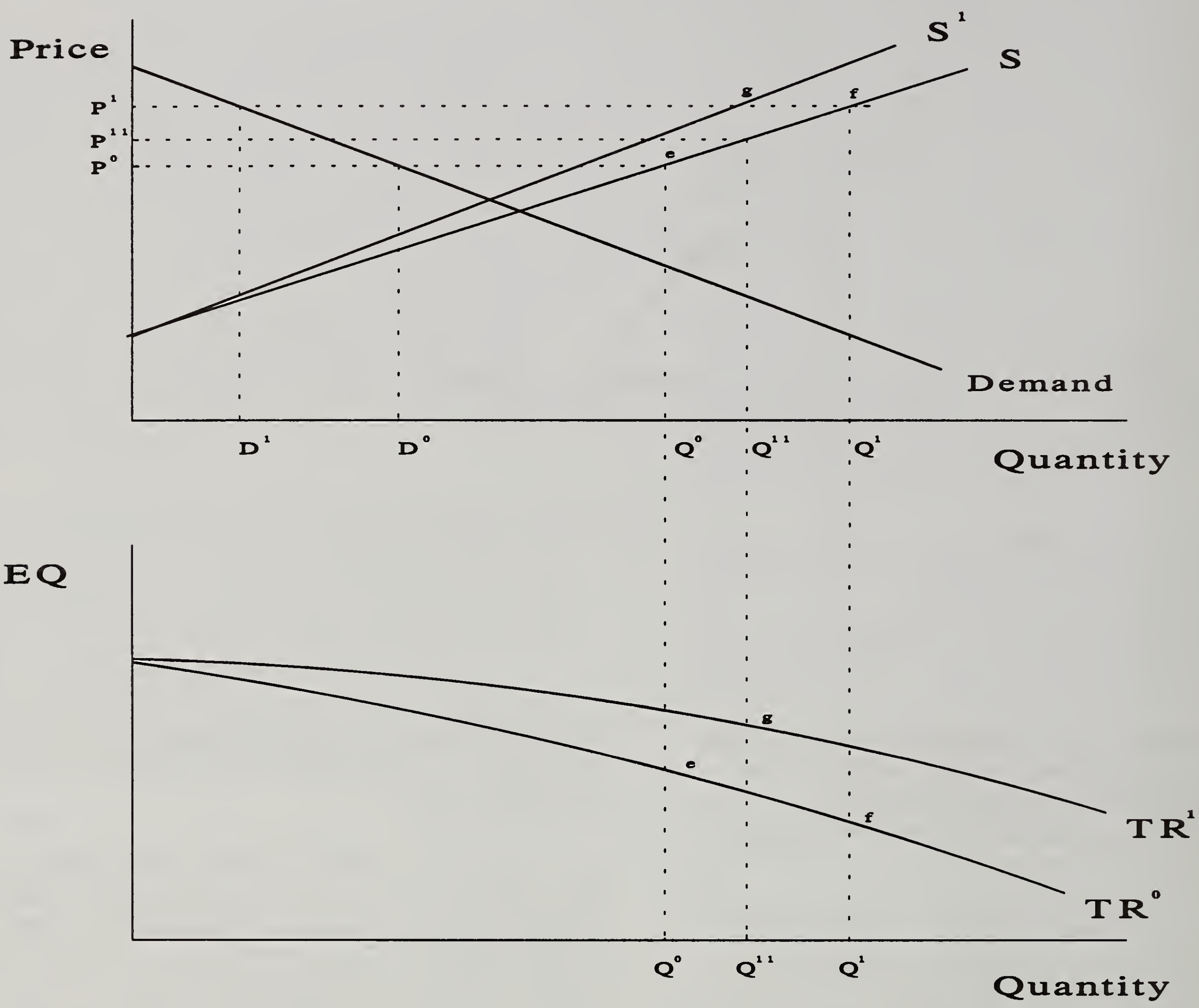
Our empirical analysis examines fruit juice trade in Western Hemisphere countries. We chose this commodity to serve as an example because of its importance in regional trade. In 1990, the United States purchased approximately $775 million or nearly 80 percent of its fruit juice imports from Latin America: 54 percent came from Brazil, 10 percent from Mexico, and 8 percent from Argentina (FATUS, USDA). The average U.S. tariff on imports of fruit juices is about 15 percent (U.S. Tariff Schedules).

Latin American fruit juice exporters rely heavily on U.S. markets. Sixty percent of Brazilian fruit juice exports, mostly composed of frozen concentrated orange juice, are shipped to the United States. For Mexico and Argentina, the United States accounts for over 90 percent and 60 percent of exports, respectively. About 80 percent of Mexican juice exports are orange juice, while Argentina's are primarily apple juice.

The environmental effect considered in this example is the health risk to farmworkers from exposure to dangerous pesticides. The U.S. Government has implemented regulations to protect farmworkers in U.S. fields from pesticide exposure. Worker protection regulations appear to be less strict and relatively poorly enforced in Latin America, although relatively little information on this topic is available (Abler and Pick; U.S. General Accounting Office). Because fruit production is so labor-intensive and because standards are lower, increased production in Latin America could lead to health problems for workers.

Figure 2

Coordination of trade and environmental policy



U.S. standards to protect farmers from pesticide exposure and to regulate the use of toxic substances for protection of health, safety, and the environment date back to the Federal Insecticide, Fungicide, and Rodenticide Act of 1947. The Act and subsequent revisions require an overall risk/benefit standard for pesticide registration and use. The legislation requires that pesticides be registered with the Environmental Protection Agency (EPA) before they are circulated in commerce or sold. The registration requires the manufacturer to supply up to 70 specific tests that are reviewed by the EPA.

If the pesticide passes EPA registration standards, it is classified according to toxicity levels: highly toxic (level I), moderately toxic (level II), and low toxic (level III and IV). When the pesticide is classified highly toxic orally, dermally, or through inhalation, the signal word DANGER in large boldface letters is placed on front of the pesticide label. Similarly, for moderate and low toxicity levels, the words WARNING and CAUTION will appear.

EPA issued standards to reduce the health risks associated with the use of pesticides in 1974 and amended these farmworker safety standards in 1991. The health risks from occupational exposures to pesticides include acute effects (such as pesticide poisoning), allergic or sensitization effects (such as skin rashes), and delayed effects (such as cancer). Standards provide for notification, training, personal protective equipment, reentry intervals, and decontamination and emergency procedures (U.S. EPA).

The notification requirements entail posting and oral warnings after application of toxicity I pesticides, and oral warnings or posting for other pesticides. The required personal protective equipment for pesticide handlers also depends on the toxicity level of the pesticide. For toxicity level I and II, the regulations require coveralls, gloves (nitrile), chemical-resistant shoes (waterproof boots), eye protection (goggles, a face shield, or safety glasses), respiratory protection (a non-disposable respirator with cartridges or a disposable dust/mist cup-style respirator) and protective headgear (a hat or a hood). Those involved in mixing and loading must also have a chemically resistant apron but not protective headgear. All of these items must be provided and cleaned by the employer. For both toxicity level I and II and for toxicity level III-IV, early entry workers need a hat, long-sleeved shirt, trousers, shoes, and socks.

The restricted entry intervals (REI) establish periods after pesticide application during which entry into a field is restricted. Only workers with protective gear may enter the field and only for short-term tasks or in emergencies.[5] Within 30 days of the end of a restricted entry interval, decontamination standards require employers to provide water, soap and towels within 1/4 mile of fields for routine and emergency washing.

The EPA Regulatory Impact Analysis is used to estimate the total costs of all farmworker pesticide safety regulations. We assumed that orange and apple production have the same cost patterns as all fruit production, with the exception of reentry intervals, and that the regulatory costs are fully passed on to juice producers. Apples and oranges have more flexible harvest times, so that additional costs of reentry intervals would be minimal. We also incorporated the regulatory costs to commercial handlers in the cost estimates, assuming that this cost is passed on to growers.

According to USDA data on pesticide use, orange and apple production use 2.1 and 1.6 percent of all agricultural pesticides applied (USDA, NASS). The total estimated producer cost per acre for these pesticide regulations is $6.09 for the first year and $3.58 for the subsequent years. Estimates for the costs of enforcing the regulations are not included, so we may be significantly understating the total regulatory cost. With the cost of production of Florida and California oranges at $1,310 and $2,292, respectively, and Washington State apples at $4,110 per acre in 1991 (Buxton), the regulatory cost share is no more than 0.5 percent and could be as low as 0.08 percent in the subsequent years.

Information on worker safety regulations and enforcement related to pesticide use in Latin American countries is limited. For this exercise, we assume that regulations do not exist or are not enforced. We also assume that if Latin American countries implemented similar worker safety regulations, the share of the regulatory costs in total production costs would be the same as in the United States. This may be an overly restrictive assumption, as Latin American farmers may employ different production techniques compared to U.S. producers. They may have a higher labor cost share than U.S. producers and may use a different mix of pesticides. Additionally, developing nations may face greater enforcement barriers than industrial countries. Therefore, different levels of expenditures on worker safety may be required to attain the same level of protection as U.S. workers receive.

Four possible scenarios correspond to points a, b, c, and d, depicted in figure 1:

(1) The removal of the tariff by the importer (United States). This action would generate the maximum additional trade revenue earned by the exporter bloc, Mexico, Argentina, and Brazil (MAB). This scenario is represented by point c in figure 1. This outcome would not, however, be acceptable to the importer because farmworker safety declines as production shifts from the United States to MAB.

(2) The removal of the import tariff and the imposition of a "maximum" environmental control policy by the exporter. A "maximum" environmental control policy is the most stringent environmental policy acceptable to the exporter. This scenario produces an outcome like point b in figure 1, where C2's gains in export revenues due to the tariff removal have been fully eroded by the imposition of the environmental control.

[5]Toxicity level I pesticides require a 48-hour restricted entry interval (REI), toxicity level II require a 24-hour REI, and all other pesticides require a 12-hour REI. Toxicity level I organophosphates require a 72-hour interval in arid areas. Toxicity level I pesticides are 30.5 percent of all pesticides applied, toxicity level 18.0 percent and all others 51.5 percent. For vegetables and fruit and nut crops, the use of toxicity level I is 33.8 percent, toxicity level II, 23.9 percent, and toxicity level III, 42.3 percent.

(3) The removal of the import tariff and the imposition of a "minimum" environmental quality control policy by the exporter. A "minimum" environmental control policy is the least stringent environmental policy acceptable to the importer. This scenario produces an outcome like point a in figure 1, where environmental quality is held at its preagreement level.

(4) The removal of the import tariff and the imposition of an environmental control policy that falls in between the minimum and the "maximum" environmental control policies. This scenario produces an outcome like point d.

Empirical simulations of scenarios (1), (2), and (4), are presented below. Scenario (3) cannot be estimated because we have not explicitly measured the relationship between the production of fruit juices and the health risks of pesticide exposure. Therefore, we cannot estimate the minimum environmental control necessary to maintain total farmworker health and safety at the preagreement level.

In order to obtain simulated outcome (1), we remove the U.S. tariff on fruit juices from MAB. The results indicate that export revenues increase by 17 percent in Mexico, 12 percent in Argentina, and 11 percent in Brazil, respectively.

To obtain simulated outcome (2), and to estimate the maximum environmental control acceptable to MAB, we first remove the U.S. import tariff. Simultaneously, we simulate an increase in the production costs of MAB until the negative effect on supply offsets the removal of the U.S. import tariff, so as to return export revenue to the base value. Using this procedure, the 'maximum' environmental taxes are estimated at 50, 45, and 41 percent, respectively for MAB. These surprisingly large rates reflect the importance of MAB to the juice market. When each of the three countries imposes additional costs on their producers, world juice supply is reduced, which raises world market prices and generates additional trade revenue. Thus, to find an outcome where there is no change in trade revenue requires a significant backward shift in MAB supplies.

To determine a simulated outcome like (4), we assume that MAB would be asked to adopt comparable worker safety regulations to those currently required in the United States. We shift the supply curves 0.5 percent for each of the three countries to capture the costs of regulations designed to protect farmworkers from pesticide exposure. This is the maximum share of worker safety costs to total production costs that we estimated for orange and apple production. With this supply curve shift, MAB trade revenue falls compared to outcome (1), but by only marginal amounts. MAB exports expand approximately 17, 12, and 10 percent, respectively. The experiment indicates, that for MAB, these additional regulatory costs are very small compared with the substantial potential gains in trade revenues.

Conclusions

Our empirical analysis is narrowly focused on fruit and one environmental issue related to its production--worker safety and pesticide use. We find that the costs to MAB of implementing worker safety regulations similar to those of the United States would be far less than the benefits to these countries of increased U.S. market access. This outcome suggests scope for broader implementation of worker safety protections in the context of a trade negotiation.

Clearly, there may be other environmental concerns connected with fruit production that are not considered in our analysis. For example, pesticide use in fruit production is a source of nonpoint water pollution that can harm humans as well as plant and wildlife habitat. Expansion of fruit production may involve increased soil erosion, especially if more vulnerable lands are brought into tillage, and rainforests are cleared. The costs of implementing policies to improve a broader spectrum of environmental indicators may exceed the acceptable limit for a country provided market access, an empirical question that needs to be further explored.

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Chapter 10

Costs and Benefits of Irradiation Quarantine Treatments for U.S. Fruit and Vegetable Imports

Kenneth Forsythe and Phylo Evangelou

This chapter examines some of the alternatives available to importers, in the event of a possible future ban on the use of methyl bromide for import treatments. Currently, methyl bromide is extensively used to fumigate imported fruits and vegetables, but its subsequent leakage into the atmosphere has been tentatively linked with possible damage to the ozone layer. As a result, a policy aimed at environmental improvement may have significant detrimental effects on agricultural trade.

Introduction[1]

Problem and Justification

The U.S. Department of Agriculture, through programs conducted by the Animal and Plant Health Inspection Service (APHIS), is responsible for protecting U.S. agriculture from pests not present or widely distributed in the United States. APHIS relies upon inspection and quarantine operations in carrying out its mission of minimizing the risk of harmful pests entering the United States.

For plants and plant products considered potential conveyors of exotic pests, fumigation using methyl bromide (MB) is the principal method of quarantine treatment. This and other uses of MB have come into question due to evidence that MB may contribute to ozone depletion in the upper atmosphere. Future production and importation of MB in the United States may be phased out under the U.S. Clean Air Act. Previous research by APHIS (Tuszynski and Grimes) indicated that the net economic losses in the U.S. fruit and vegetable market from potential MB cancellation and consequent import bans on nine selected commodities could approach $1 billion over 5 years.[2] This research was known as the NAPIAP study, an acronym for National Agricultural Pesticide Impact Assessment Program.

This issue is illustrative of how changes in environmental regulations and policies can affect agricultural trade. The elimination of processing methods deemed harmful to the environment can reduce or eliminate trade in certain products if no alternative processes are available or if the available alternatives result in substantially higher costs to suppliers of foreign products. Possible alternatives to MB fumigation are discussed below.

More than 350-million kg of imported produce (95 percent of it fruit) were fumigated at U.S. ports during FY 1991.[3] During this same year, an approximately equal quantity of produce was precleared before shipment to the United States. Most precleared produce is inspected and, if no pests are found, approved without treatment. However, preclearance of some commodities entails mandatory treatment at the point of origin, such as fumigation of grapes from Chile (nearly 69 million kg at the point of origin, compared with 244 million at U.S. ports in FY 1991) and hot-water immersion of mangoes from various Latin American countries (over 92 million kg at the point of origin).

The importance of MB fumigation is underscored by the seasonality of the fruit treated. Some fumigated imports of apricots, grapes, nectarines, peaches, and plums from Chile, for example, enter the United States in winter months when U.S. production is zero or near-zero. Domestic production could not replace lost imports of these commodities during these months. If consumption levels are to be maintained, other treatment methods will need to be applied.

[1]The authors are, respectively, an agricultural economist formerly in the Economic Research Service and currently in the Animal and Plant Health Inspection Service and an agricultural economist in the Animal and Plant Health Inspection Service of the U.S. Department of Agriculture. This paper is a condensed version of an ERS Staff Report.

[2]Calculated as the present value (in 1987 dollars) of annual changes in consumer and producer surplus over 5 years.

[3]This total does not include produce fumigated during preclearance.

Objective

The objective of this study is to examine the economic costs and benefits of irradiation as a treatment alternative to methyl bromide fumigation. Considerable research on irradiation as a quarantine treatment has focused on determining appropriate dosage levels to ensure phytosanitary protection. Along with evaluating its technical efficacy, the relative costs of irradiation are central to assessing its potential as a treatment alternative.

This paper presents analysis of economies of size, investment costs, and per unit costs of irradiation at the volumes required at individual U.S. ports of entry. Economic benefits are assessed in terms of offsetting some of the potential economic losses in U.S. fruit and vegetable markets from cancellation of MB's registered uses as an import fumigant. The analysis is based on average annual data for fiscal years 1985 through 1987 and illustrates the economic effects of hypothetical changes in environmental and phytosanitary regulations, given the conditions during that period. For further details on methods and results, see the ERS staff report by Forsythe.

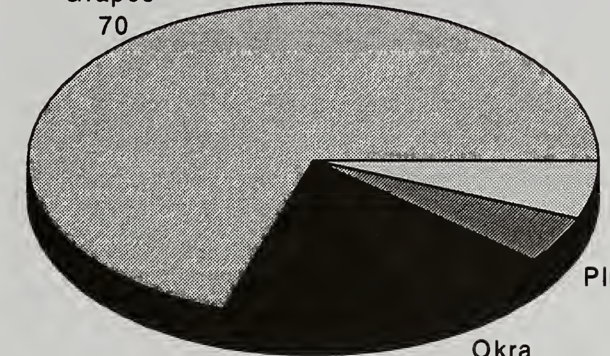
Procedures for Analysis

Research by Tuszynski and Grimes examines the effects in the U.S. fruit and vegetable market of a possible import ban on nine selected commodities resulting from MB cancellation. Our analysis extends this research to include the economic effects in several U.S. fruit and vegetable markets of replacing MB fumigation with treatment by irradiation. Quarantine treatments for U.S. imports of grapes, nectarines, peaches, okra, and plums are analyzed in this study. These commodities, imported primarily from Chile and Mexico, account for 94 percent of U.S. fruit and vegetable imports for which there is no approved alternative to MB fumigation (figs. 1 and 2).[4] The importance of quarantine treatments for the commodities examined is emphasized by the seasonality of the fruit treated (fig. 3).

The base year for the Tuszynski and Grimes study and for the present analysis is an average of fiscal years 1985 through 1987. All prices and values are adjusted to 1987 dollars. Following procedures used by Tuszynski and Grimes, the

Figure 1

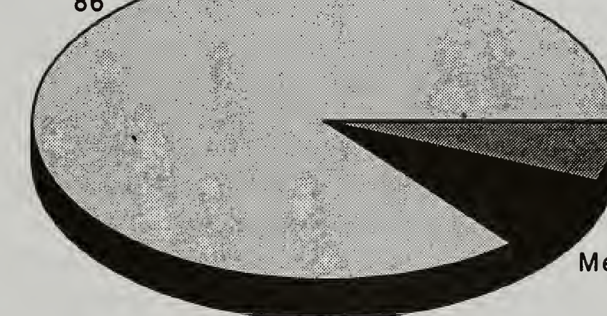
U.S. fruit and vegetable imports requiring methyl bromide fumigation



Annual average share of fumigated imports by crop, FY 1985-87.

Figure 2

Fruit and vegetable exports to the U.S. requiring methyl bromide fumigation



Annual average share of fumigated exports by country, FY 1985-87.

welfare effects reported in the "Results" section below, are the present value of annual changes accumulated over a 5-year period. The welfare effects are based on the posited changes in phytosanitary regulations, assuming no unrelated production or consumption effects over the 5-year period. This assumption isolates the effects of the changes in the phytosanitary regulations.

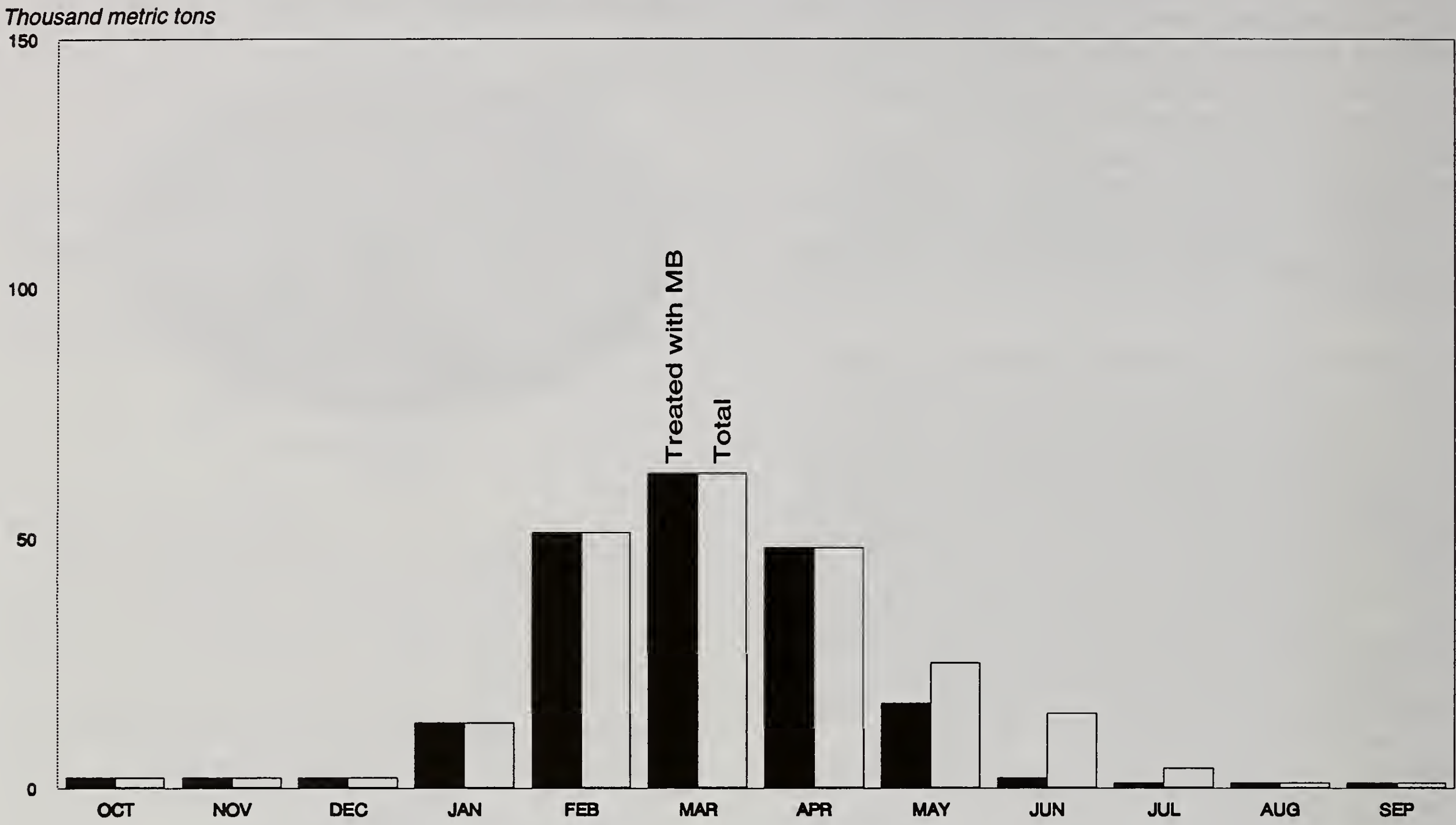
Measuring Welfare Effects

Figure 4 illustrates conceptually the effects of potential changes in phytosanitary trade

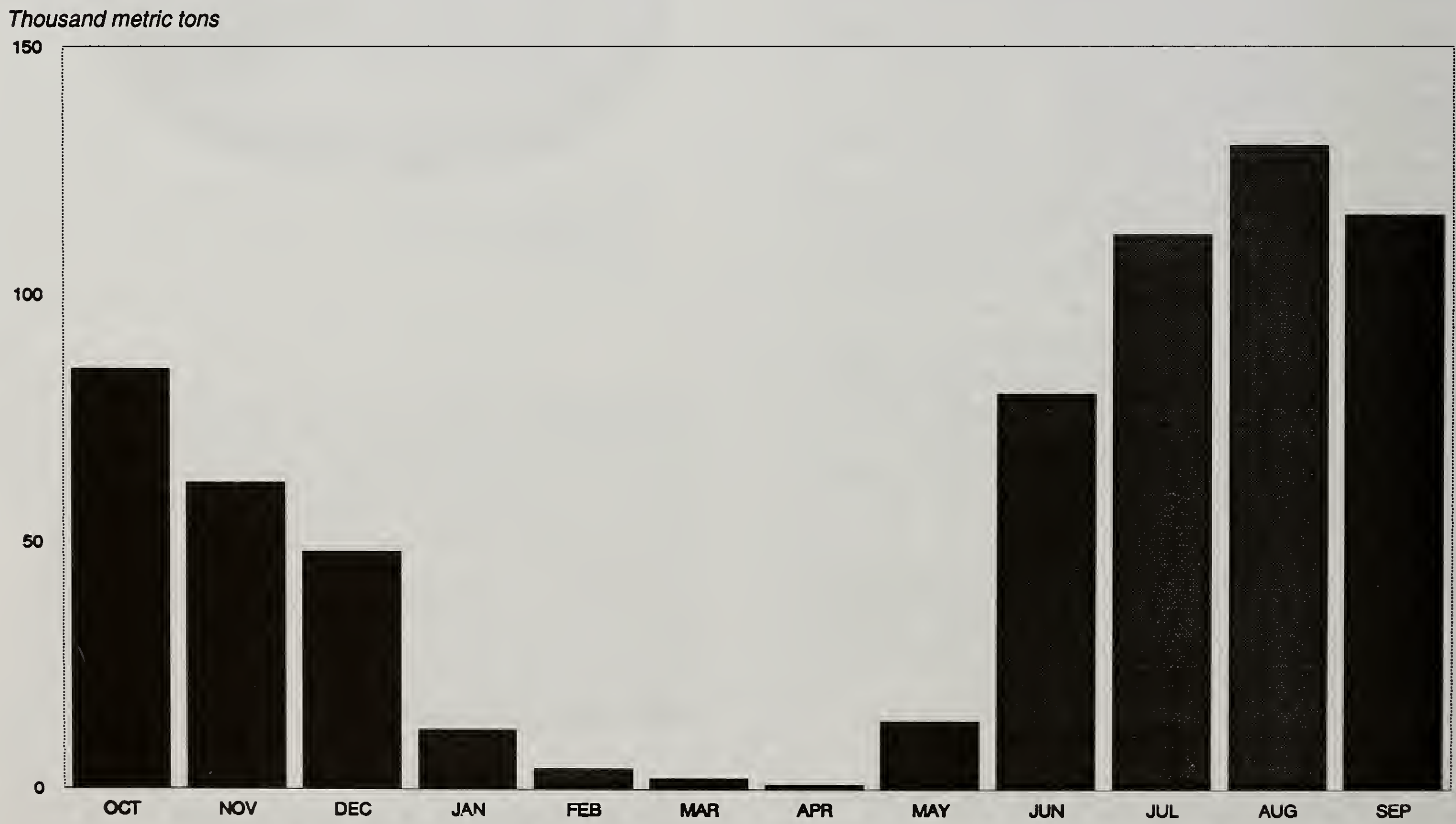
[4]Percentage calculated by annual average weight of imports in fiscal years 1985 through 1987.

Figure 3

U.S. grape imports under quarantine regulations



U.S. grape production



Annual averages, FY 1985-87.

regulations for off-season fruit and vegetable imports. The upper panel shows the effect of an import ban on commodities exported from affected countries (countries where pests present a phytosanitary risk to the importing country). The lower panel shows the effect of changes in the costs of required import quarantine treatment for such commodities. The transfers of welfare illustrated occur within the market for a single commodity. In this analysis we are concerned only with welfare changes in the importing country and tracking the transfer of this welfare to other agents in each market.

The label definitions for figure 4 are as follows: S and D are domestic supply and demand, respectively, ED is excess demand, ES^{NA} is the excess supply of nonaffected countries, Z represents imports from nonaffected countries, t represents required treatment costs. The excess supply of affected countries is assumed to be perfectly elastic at price P^x. Q is the total quantity supplied, both domestic and foreign, in the importing country. The superscript "o" refers to the current situation, "b" refers to the situation where the importer imports only from nonaffected countries, and "m" refers to the situation after an increase in treatment cost. The superscript "x" refers to a situation where treatment costs equal zero. As discussed below, this situation is used as a reference point in the analysis for calculating welfare and revenue changes. Aggregate excess supply for affected and nonaffected exporters is assumed to be perfectly elastic, as discussed in the "Limitations of the Analysis" section below. Following Tuszynski and Grimes, U.S. domestic off-season supply is assumed to be perfectly inelastic because off-season production is very low relative to overall production, and thus, the response of domestic supply to price changes is expected to be minimal.

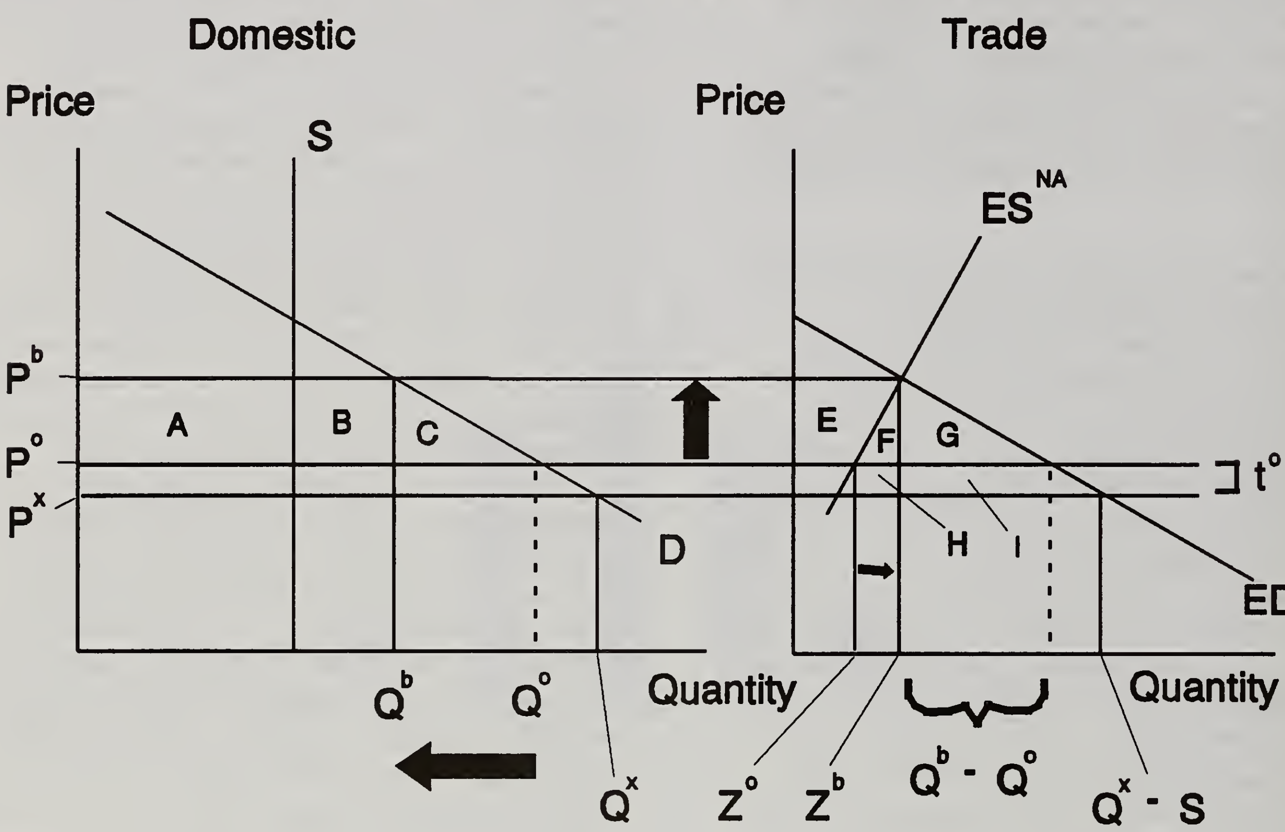
In the import ban scenario, as proposed by Tuszynski and Grimes, the price change is equal to P^b - P^o because of decreased import levels resulting from a ban on imports from affected countries. Economic welfare is transferred from consumers to owners of fixed factors of production (represented by area A in the upper panel of figure 4) and to exporters in nonaffected countries (represented by area EF or equivalently by area B). Some consumer surplus is lost to the economy as deadweight (represented by area G or equivalently by area C).

In an alternative scenario to that proposed by Tuszynski and Grimes, the costs of required treatment increase from substituting an alternative technology (irradiation for MB fumigation). The resulting price change is equal to P^m - P^o because of the increased cost. Economic welfare is transferred from consumers to owners of fixed factors of production (represented by area L in the lower panel of figure 4) and to exporters in nonaffected countries (area OR). Area OR is transferred as revenue to nonaffected exporters of which area O represents a welfare gain. Some consumer surplus is lost to the economy as deadweight (area U). Economic welfare is transferred from consumers and received by providers of the treatment service as a revenue gain (area TW - VWX). With the higher treatment cost, the transfer of welfare from consumers to treatment providers declines by VX because of decreased import quantities from affected countries, but increases by T because of the increased cost. Area V is recovered as revenue to nonaffected exporters. Area VR represents a portion of the variable costs of producing the additional exports (Z^m-Z^o) of nonaffected exporters and therefore does not contribute to welfare gain in these countries. Whether the net change for treatment providers is positive or negative depends on the slope of the excess demand curve and the slope of the excess supply curve for nonaffected exporters. The amount of revenue lost to treatment providers as a result of decreased imports (area X) contributes to the change in deadweight loss within this market. The change in welfare losses in the importing country (including revenue to treatment providers) that cannot be tracked as transfers of welfare or revenue to other agents in the market is measured as area UXY (after the change) less area Y (before the change). We will define this area as "other deadweight loss." The net change in the importers welfare from the higher treatment cost is area ORUVX.

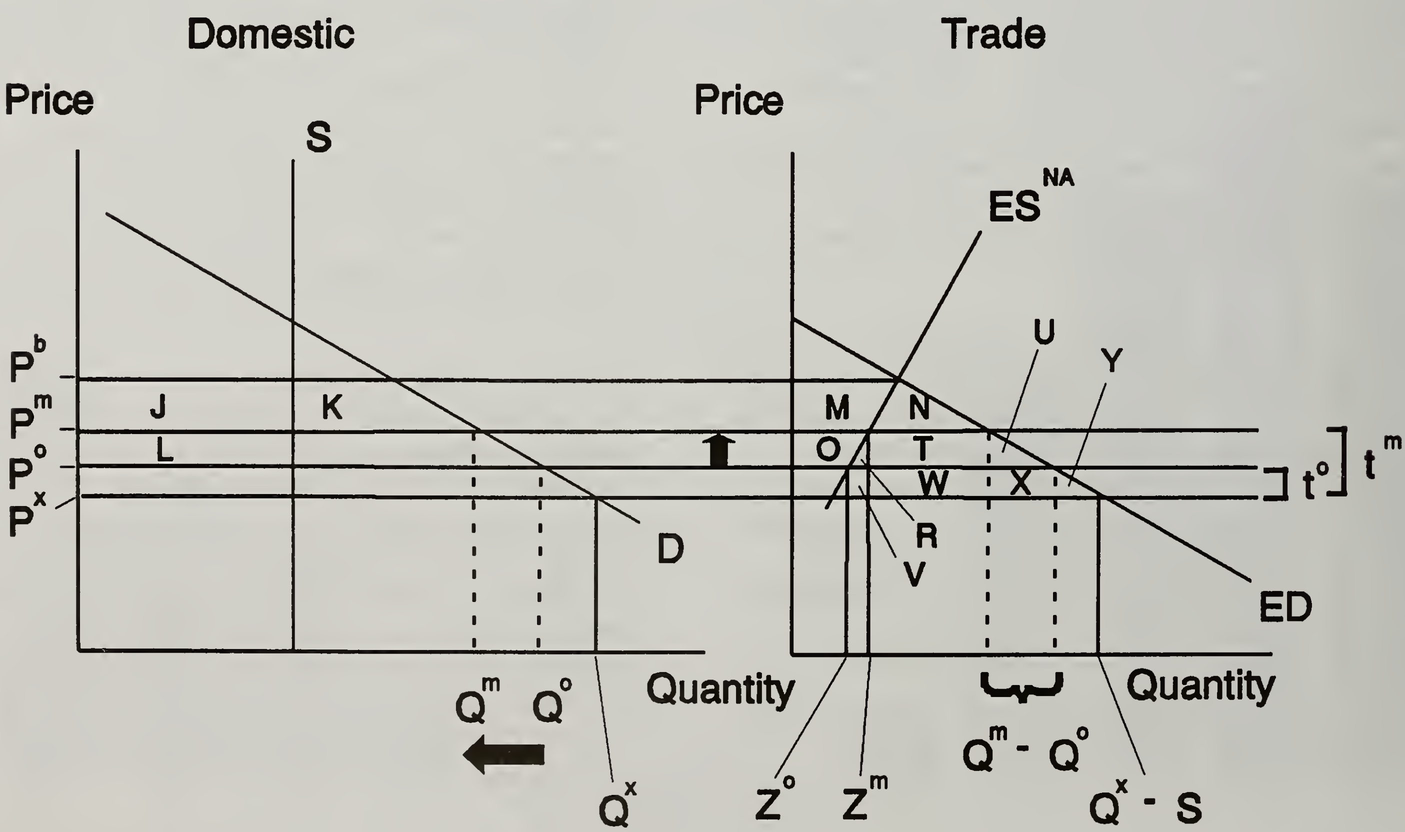
We include lost revenue of treatment providers as part of net welfare loss because we are measuring welfare changes in individual markets. Returns to providers of import treatment services are part of those markets and are clearly lost to those markets if imports from affected countries are banned. Whether the resources involved in providing those services (some of which are equipment and facilities specifically designed for fumigation) can be absorbed elsewhere in the U.S. economy is beyond the scope of our study.

Figure 4.
Conceptual framework of a change in phytosanitary trade regulations for off-season fruit and vegetable imports.

Effect of an import ban on affected countries



Effect of a change in treatment costs (t)



Area MN plus area TW in the lower panel of figure 4 is a measure of economic welfare that would be lost to the importing country if the method of treatment (corresponding to treatment cost t^m) were not available nor were any alternatives. Recall that, for the imported fruits and vegetables examined in the present study, methyl bromide fumigation is the sole treatment currently available and will likely be banned. We examine irradiation, though not currently approved as an import quarantine treatment, as a possible alternative. The economic benefit to the importing country of having irradiation is measured relative to the situation where the importing country imports only from nonaffected exporters. This measurement represents a partial offset of the economic losses that would occur under the import ban scenario proposed by Tuszynski and Grimes, illustrated in the upper panel of figure 4. It can be seen from examining figure 4, that if the cost of irradiation as an import treatment were sufficiently high and/or the supply response of nonaffected exporters were sufficiently elastic, then the economic benefit of having this treatment method could be minimal or nonexistent. This economic benefit from using the higher-cost treatment (t^m) rather than having imports banned from affected countries, as illustrated in figure 4, is calculated as the sum of consumer welfare gains (area JK in the lower panel) and producer welfare losses (area J) due to trade with the affected countries plus revenue to domestic treatment providers (area TW). Note that area JK - J equals area MN in figure 4. We define area NMTW as the gains from trade with affected countries of using irradiation as an import quarantine treatment.

The welfare changes illustrated in figure 4 can be measured by assessing the price and quantity changes for each commodity that result from changing phytosanitary trade regulations. Base prices and quantities were adjusted from observed levels (P^o, Q^o in figure 4) to levels expected if no treatment were required (P^x, Q^x).

The base-price elasticity was correspondingly adjusted. These adjustments were made because of the uncertainty surrounding the cost estimates for the MB fumigation currently being used. This uncertainty yields a similar doubt about the base price upon which to assess the cost of irradiation treatment.

Cross-commodity price effects are assumed to be negligible, because the off-season imports of each commodity considered are concentrated at different times of the year. The welfare changes and transfers measured occur within the market for the specific commodities analyzed. Such externalities as the benefits of reduced ozone-depletion from eliminating methyl bromide fumigation, are not explicitly considered.

The quantity change in imports resulting from an import ban is assessed as follows. The initial quantity reduction is the quantity imported from countries affected by the ban (Q^o - Z^o less domestic supply at the beginning of the period of analysis as shown in figure 4). These imports enter the United States during months when few other countries are able to produce these commodities. Furthermore, some potential producers are not able to export to the United States because of phytosanitary restrictions. Following Tuszynski and Grimes, it is assumed that 5 percent of U.S. grape and plum imports and 10 percent of U.S. nectarine and peach imports lost, due to changes in phytosanitary regulations, are replaced from other sources in equal annual increments over a 5-year period.[5] Note that Q^o - Z^b less domestic supply is equal to Q^b - Q^o in figure 4. The present value of the resulting annual changes in welfare effects are summed over the 5-year period.

Assessing a change in import quarantine treatment costs is more involved than the assessment of an import ban. Increased treatment cost adds to the cost of importing the commodity from affected countries. The estimated change in treatment cost is used to approximate the price change in the domestic market.[6] The change in treatment cost is held constant over the 5-year period of analysis. The quantity Z^m - Z^o in figure 4 is incrementally allocated from affected exporters to nonaffected exporters over the 5-year period in calculating areas O,R,T,V, and W to account for nonaffected exporters supply response to the price change. Procedures for estimating the treatment cost t^m are described in the staff report.

Limitations of the Analysis

This analysis is limited to short- to medium-term costs and benefits of irradiation disinfestation in off-season U.S. markets for grapes, nectarines, peaches, okra, and plums. Externalities (such as reduced ozone-depletion) are not explicitly

[5]See Tuszynski and Grimes for details on the assumptions and potential sources of replacement imports.

[6]The implications of this approximation are discussed in the "Limitations of the Analysis" section below.

considered, nor are welfare changes in other markets that might result from cross-price effects.

The results discussed below are based on the trade pattern and average annual import volumes at individual U.S. ports of entry that existed during fiscal years 1985-87. It is presupposed that all imports that required treatment with methyl bromide in the base period will require treatment with irradiation at the port of entry. This is equivalent to assuming an instantaneous change in the base period from methyl bromide fumigation to irradiation at all ports of entry simultaneously. In reality, if only a few ports of entry developed irradiation capability, initially, imports might be diverted to them. Assuming that the larger ports developed irradiation capability first, this could increase the economies of size captured and decrease per unit disinfestation costs.

This analysis deals with off-season imports during the time of year when U.S. production is a very small fraction of overall production. Following Tuszynski and Grimes, we assume for analytical purposes that domestic U.S. production is perfectly inelastic in the off-season. This is justified if we can reasonably assume that the effect of off-season price changes on domestic production decisions is negligible relative to any changes that may occur in-season. Therefore, any error introduced by this assumption should be extremely minor and would not affect our conclusions. To isolate the effects of the posited changes in phytosanitary regulations, we further assume that there are no production or consumption effects unrelated to changes in off-season import quarantine treatment costs over the 5-year period analyzed.

The results presented are based on the assumption that the price change in domestic markets is equal to the average change in treatment cost. This is equivalent to assuming a perfectly elastic aggregate foreign excess supply curve. This results in a greater price change due to increased treatment costs from replacing methyl bromide fumigation with irradiation than would be expected if the aggregate foreign excess supply were less than perfectly elastic. As a result, the transfers from U.S. consumers to other agents in the commodity market may be overstated and the gains from trade with affected countries may be understated. Since we conclude below that under these conditions irradiation is economically feasible (that is, that substantial gains from trade with affected countries are captured with minimal transfers from U.S. consumers) then this conclusion will hold regardless of the actual excess supply elasticity.

The fruit and vegetable markets in Chile and Mexico would be the foreign markets most affected by changes in U.S. phytosanitary import regulations (fig. 2). Chile, in particular, is very export dependent. A decrease in the price received for fruit and vegetable exports by producers in these countries would be expected to transfer welfare from these producers to foreign consumers. An analysis of the dollar values of these effects in exporting countries is beyond the scope of this study.

The results shown below are based on the assumption that there are no shifts in demand resulting from consumer preferences for produce treated with methyl bromide versus irradiated produce. Consumer acceptance of irradiated foods is an open question, though some evidence suggests a positive consumer response (Katzenstein, Loaharanu). An analysis of consumer preferences for chemically treated versus irradiated foods is beyond the scope of this study.

The estimates of treatment costs and welfare transfers presented in this analysis are generalizations intended to suggest the magnitude of the net gains to the United States from trade with countries affected by changes in costs of import quarantine treatment.

Results

The economic effects of an import ban on fresh fruits and vegetables requiring MB fumigation are consistent with results obtained by Tuszynski and Grimes.[7] We estimate the economic cost to the United States of such a ban is approximately $1.1 billion over the 5-year period analyzed. The change in consumer surplus is calculated as area ABC, as illustrated in the upper panel of figure 4. The change in producer surplus is calculated as area A. The net change in consumer and producer surplus in each market is thus area BC, or equivalently area EFG. Area EF of this net change is captured by exporters in nonaffected countries and the remainder (area G) is lost to the economy as deadweight. The loss of returns to treatment providers due to a ban are calculated as area HI. Our estimate of net U.S. losses due to MB's

[7]These results are based on the assumptions delineated above regarding replacement of imports from nonaffected sources over a 5-year period.

cancellation (area EFGHI) is somewhat higher than Tuszynski and Grimes' because of the inclusion of okra in the analysis and accounting for the revenue losses of providers of treatment services.

We report the lost revenue of treatment providers as part of net welfare loss because we are measuring welfare changes within individual markets. Returns to providers of import treatment services are part of those markets and are clearly lost to those markets if imports from affected countries are banned. Whether the resources involved in providing those services (some of which are equipment and facilities that are specifically designed for fumigation use) can be absorbed elsewhere in the U.S. economy is beyond the scope of our study.

The estimated levels of irradiation treatment costs, ranging from 1.3 to 3.2 U.S. cents per pound, are largely the result of the concentration of imports requiring treatment at several ports of entry. This concentration allows irradiation facilities to capture substantial economies of size in treating most imports and helps keep the weighted average of per unit costs down. These estimated costs are represented by t^m in the lower panel of figure 4.

Results from four scenarios are discussed. The different scenarios employ different assumptions about the costs of fumigating fruits and vegetables with methyl bromide and the phytotoxic effects of irradiation on grapes. All of the scenarios reflect the expected increase in treatment costs (t^m - t^o) from using irradiation rather than methyl bromide fumigation.

The results from analyzing the four scenarios illustrate the relative magnitudes of the gains to the United States from trade with countries affected by U.S. phytosanitary measures and the welfare transfers among different sectors of the U.S. economy caused by a change in these measures. All values are the present value of sums over 5 years, assuming a 10-percent discount rate.[8]

For each of the four markets analyzed, the gains to the United States from trade with affected countries of using irradiation in the absence of any other approved treatment are calculated. These gains from trade, which range from about $650 million to $1.1 billion (present value over 5 years), represent the portion of the potential economic losses that could occur from an import ban on commodities requiring MB treatment (as posited by Tuszynski and Grimes) that could be offset by using irradiation as an import quarantine treatment. Since the analysis is limited to welfare changes in individual markets and all import quarantine treatments are assumed to take place at U.S. ports of entry, the revenues generated by import treatment providers in the United States are included in the gains from trade calculation. However, these revenues are a minimal portion (1 to 2 percent) of the value calculated. The gains from trade with affected countries are calculated as area MN plus area TW as shown in the lower panel of figure 4.

[8]The 10-percent discount rate was chosen to be consistent with the Tuszynski and Grimes analysis.

Conclusions

The regulatory changes analyzed are hypothetical and are posited to reflect public concern over the ozone-depleting potential of methyl bromide and the possible cancellation of its registrations in the United States. MB fumigation is currently the only APHIS-approved import quarantine treatment available for the commodities analyzed in this study. Irradiation is not currently approved for import disinfestation by the USDA Animal and Plant Health Inspection Service (APHIS), and additional research will be required before approval can be obtained. Along with evaluating its technical efficacy, the relative costs of irradiation are central to assessing its potential as a treatment alternative.

Imports requiring methyl bromide fumigation are concentrated in several of the 39 U.S. ports of entry examined in this study. This concentration allows substantial economies of size to be captured in the use of irradiation as an import quarantine treatment.

Grapes constitute 70 percent of the U.S. fresh fruit and vegetable imports that require methyl bromide fumigation and for which there are no currently available alternatives. Therefore, the phytotoxicity of irradiation with respect to grapes and the appropriate minimum required dose for grape disinfestation are important issues deserving of further research. Though economies of size are still realized, per unit costs for irradiation disinfestation of nectarines, peaches, and plums more than double without accounting for grapes. Irradiation disinfestation costs for okra remain nearly unchanged, because few ports of entry handle both grapes and okra.

Given the assumptions upon which this analysis is based, irradiation as an import quarantine treatment can generate net gains from trade with countries where exotic pests present a phytosanitary risk. These gains range from $650 million to $1.1 billion over the 5-year period analyzed. Clearly, the magnitude of these gains far exceeds the consumer losses and the net losses possible from using irradiation to replace methyl bromide fumigation in the U.S. fruit and vegetable markets examined. From a broader view, additional U.S. benefits are realized from ensuring the phytosanitary security of the domestic food supply, and from the elimination of a phytosanitary measure (MB fumigation) that has been recognized as potentially harmful to the ozone layer.

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Chapter 11

The EC Nitrate Directive and its Potential Effects on EC Livestock Production and Exports of Livestock Products

Dale Leuck

This chapter analyzes the effects of the regulation passed by the environmental ministers of the European Community, limiting the application of nitrogen-containing manure and chemical fertilizers in areas where nitrate levels are already high. Some areas of the EC are to be designated "vulnerable zones," where such applications must be reduced. Restrictions on livestock density in these regions are expected.

Introduction

Intensive agricultural practices are widely recognized as sources of water pollution in the European Community (EC).[1] The most serious pollutant is nitrate, derived from nitrogen contained in both commercial fertilizer and livestock manure.[2] However, livestock manure is widely viewed as the more problematic source of nitrate, because it is generally treated as waste by farmers and not as productive an input as fertilizer.

The EC Nitrate Directive was legislated in 1991 to regulate the amount of nitrate entering water supplies (Commission of the European Communities, 1991), after an 8-year phase-in period. The Directive specifies that nitrogen from manure be reduced in regions that have the most severe nitrate problems. Such reductions are to be consistent with the uptake of nitrogen by crops and the use of fertilizer. Provisions are to be made for establishing more efficient systems of manure storage and disposal, but much of the nitrogen reduction will likely require reductions in livestock numbers in some regions. Thus, the Directive may reduce EC exports of livestock products.

The objectives of this paper are to: describe and measure the nature, extent, and magnitude of the nitrate problem in the EC; describe the general provisions of the Nitrate Directive; and calculate possible reductions in livestock numbers and livestock trade. While the Directive addresses the problem on a regional basis, both the measurement of the problem and the calculations of possible reductions in livestock numbers are done on a country basis because of data limitations. These reductions are calculated using nitrogen-content coefficients (Koopmans). They are then compared with recent trade statistics to assess the impacts on livestock exports.

The year 1986 is used as the base for calculating the reductions in livestock numbers. This method is consistent with data in the models used by others (Haley; Leuck and coauthors) to more completely examine the international trade effects of the Nitrate Directive. Their research compares the effects of the Nitrate Directive, a nitrogen tax, and Common Agricultural Policy (CAP) reform on EC trade, world prices, and trade with the United States. Some of these effects are summarized by Haley in Chapter 12 of this report.

EC Trade in Livestock Products

Livestock production has become more intensive since the 1950's, as demand has increased and the CAP has provided favorable price supports. For example, the supply of dairy products, beef, and veal has more than doubled between 1950 and the present; while pork and poultry production has more than tripled. Such growth has resulted in the EC shifting from being a net importer to being a net exporter of all major livestock products except sheepmeat and wool over the last 30 years.

The current export position of the EC-10, as measured by the self-sufficiency data in table 1, reveals that some countries depend more on

[1]This report only covers the EC-10: Belgium; Luxembourg; Denmark; Germany; France; Ireland; Italy; The Netherlands; and the United Kingdom. Although agriculturally induced water pollution is increasing in Spain and Portugal, the problem in these countries is relatively moderate.

[2]While livestock manure may also function as a fertilizer, the distinction is made between livestock manure and commercial fertilizer in order to distinguish between them as sources of nitrogen.

Table 1—Self-sufficiency, selected livestock products, EC-10, 1991-92 average

Country	Beef and veal	Butter	Cheese	Dry milk	Pork	Poultry meat	Eggs	Sheep meat
				Percent				
Belgium/Luxembourg	149	124	35	182	176	115	126	32
Denmark	197	188	368	120	373	216	103	40
Germany[1]	119	98	88	253	85	62	74	62
Greece	35	58	88	0	71	99	98	88
France	107	104	117	133	90	138	99	59
Ireland	852	819	425	1,559	135	95	76	287
Italy	76	78	82	0	74	98	94	79
Netherlands	194	174	294	27	257	205	339	116
United Kingdom	86	64	67	202	68	97	97	90
EC-10	110	111	109	132	105	108	102	83

[1] Excludes the former East Germany.
Source: Western Europe Agriculture and Trade Report.

exports than others. Out of the eight products in table 1, the EC exceeds self-sufficiency in seven. Self-sufficiency is exceeded by The Netherlands and Denmark for seven products; by Belgium and Ireland for six products; and by France for five products. Germany and the United Kingdom exceed self-sufficiency in only two products and one product, respectively. Italy and Greece are not self-sufficient in any products.

These data cannot describe the influence of EC trade on world markets, but this influence is significant for most products, as demonstrated by Roningen and Dixit. Since a large share of EC products are exported, any policy that affects EC production may also significantly affect world trade.

Nitrate: A Plant Nutrient and a Source of Pollution[3]

Nitrate is a form of nitrogen that can be directly absorbed by plants. Nitrogen is essential for plant growth because it aids in photosynthesis. However, much of the nitrate in the soil is not absorbed by plants and may ultimately enter ground or surface water by leaching or runoff.

Nitrate that enters ground or surface water contributes to eutrophication, which is defined as an excess of any nutrient. Excess nutrients in surface waters precipitate algae blooms, which have a disagreeable odor and may be toxic if ingested. The algae blooms also compete with normal aquatic life for the limited oxygen content of the water. The most common sources of eutrophication in water supplies are nitrate and phosphate.

Nitrate may also adversely affect both livestock and human health (Follott and coauthors). High levels of nitrate interfere with the metabolism of livestock, leading to reduced feeding efficiency. The main human health concern with nitrate is its possible linkage to stomach cancer. In very large concentrations, exceeding 100 parts per million (ppm), nitrate may also cause respiratory failure in infants because their blood takes up nitrate rather than oxygen.

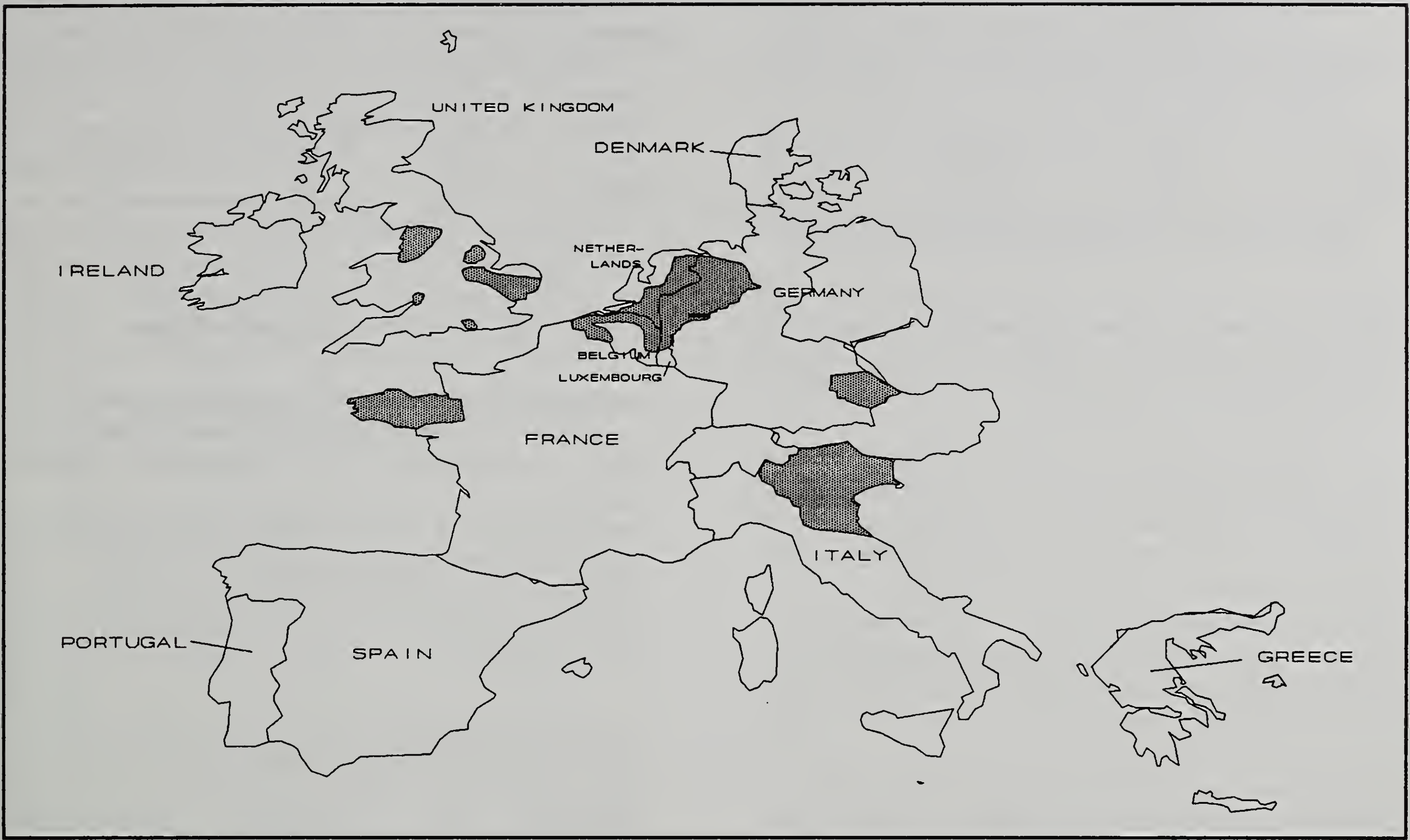
Sources and Uses of Nitrate

Nitrate is derived from elemental gaseous nitrogen, N_2, through a number of chemical reactions. Elemental nitrogen makes up approximately 78 percent of the atmosphere. To be used by plants, elemental nitrogen must be "fixed" into some other form and placed into the soil where it can be absorbed by plant roots.

The most important source of fixed nitrogen is the fertilizer industry, which produces both liquid and

[3]A discussion of the role of the nitrogen cycle in producing and reducing nitrate in the soil may be found in Follott and coauthors.

Figure 1
Areas of surplus animal manure



solid nitrogen fertilizer.[4] Anhydrous ammonia is the most important form of liquid nitrogen fertilizer, and is also used to create ammonium nitrate, the most important source of solid nitrogen fertilizer. Except for ammonia, most forms of nitrogen undergo additional reactions before being absorbed by plants in the form of nitrate.

Livestock manure is the second most significant source of nitrogen. The nitrogen content of livestock manure is derived from the feed consumed by the livestock.

Nitrate eventually exits the soil in several ways. Sutton and coauthors report that up to 30 percent of the nitrogen in manure spread on fields in Indiana (United States) may return to the atmosphere through volatilization. Some volatilization may also occur with fertilizer if not properly applied. Volatilization is highly influenced by soil and weather factors.

[4]Less important sources of nitrogen are electrical storms, automobile exhausts, industrial emissions, and the symbiotic relationship that exists between legumes, such as cover and soybeans, and certain bacteria that live in the soil.

The leaching of nitrate is influenced by the structure of the soil (that is, sandy), its content of organic matter, the amount of rainfall, and the density of the plants. Leaching may occur fairly rapidly under some conditions, but take several decades under others. An Agra Europe report notes that in Europe up to 50 percent of soil nitrate may leach into water supplies in regions having light, sandy soils, heavy rainfall, and a high water table. This occurrence is within the range of estimates of nitrogen loss in a survey of studies by Scharf and Alley.

Nitrate Pollution in the EC

In response to increasing concerns about nitrate levels in water supplies, the EC Drinking Water Directive was passed in 1980 (Commission of the European Communities, 1980). This Directive established a maximum allowable concentration (MAC) of 50 ppm of groundwater as safe, although it did not legislate ways to maintain nitrate levels below the MAC. Several EC countries have policies aimed at limiting nitrate levels in their water supplies to the MAC. A

Table 2—Cattle and pigs per UAA, selected countries, 1989

	Belgium	Netherlands	Denmark	Germany	France	Italy	United Kingdom
				Head			
Cattle	2.29	2.36	0.79	1.23	0.70	0.51	0.65
Pigs	4.75	6.80	3.27	1.90	.45	.54	.40

Source: Commission of the European Communities, 1988.

widely held belief is that the MAC may be achieved with average application rates of 127 kilograms per hectare (kg/ha) of nitrogen.[5]

Agra Europe describes nitrate problems in the low-lying areas of Belgium, France, The Netherlands, the north of Italy, part of Germany, and parts of southern England (fig. 1). Nitrate pollution in Denmark has been significantly reduced in recent years because of Danish Laws. High levels of nitrate in these regions are viewed as problems of surplus manure because fertilizer use is calibrated to the optimal uptake by plants.

Most nitrate that enters the environment in the problem regions comes from cattle and pigs. The countries with nitrate pollution extending over relatively large regions have higher densities of cattle and pig production per hectare of utilizable agricultural area (UAA) than other countries. For example, Belgium, The Netherlands, Denmark, and Germany have more cattle and pigs per UAA than the other countries in table 2.

In Germany, the residual amount of nitrate left in the soil after plant uptake is accounted for has increased from 10 kg/ha to more than 100 kg/ha in the last 20 years (Agra Europe). In the former West Germany, about 5 percent of delivered drinking water exceeds the MAC; about 2 percent of French drinking water is in excess of the MAC; and in The Netherlands the average nitrate concentration found in groundwater 30 meters below sandy soils contains an average nitrate concentration of 106 ppm (Manale). Since it may take decades for residual nitrate to leach into groundwater, these measurements understate the nitrate problem.

[5]It is ambiguous whether the 127 kg/ha refers to the amount of nitrogen applied or to the residual left in the soil after plant uptake, since no reference to this number is provided in Agra Europe. Since suggested amounts of nitrogen range from 125 kg/ha for spring barley in the United Kingdom to 400 kg/ha for silage in The Netherlands, it apparently refers to residual.

EC Environmental Policies

Several national policies have been enacted in countries with especially severe nitrate problems in order to meet the MAC of the 1980 Water Directive (Commission of the European Communities, 1980). Denmark and The Netherlands have the most stringent national legislation in the EC. However, nitrate pollution shows up outside the countries of origin and requires cooperative, EC-wide solutions.

The main principles of the EC's environmental policies evolved from the United Nations Conference on the Human Environment, held in Stockholm in 1972. In response to pressure from the EC Parliament, environmental groups, and some member governments, the EC Commission proposed legislation in 1988 intended to reduce the accumulation of nitrate in water supplies. After 2 years of debate, the Nitrate Directive was passed by the Council of Environmental Ministers on June 14, 1991.

While many details are yet to be finalized, the general intention of the Nitrate Directive is to limit the nitrate levels in water from exceeding the MAC (Commission of the European Communities, 1991). Regions having excessive amounts of nitrate, known as "vulnerable" zones, are to be designated by member countries within 2 years. Member countries must also draw up "codes of good practice," required in the vulnerable zones and voluntary elsewhere. The minimum requirements for these codes are set out in the regulation, but member countries may legislate stricter codes. Records of nitrogen application in these zones must be maintained by the member governments.

After the vulnerable zones are designated, countries have an additional 2 years in which to design programs to reduce nitrate levels to the MAC. Countries are granted flexibility in the design of these programs, however. These

programs are to be implemented over an additional 4-year period. Thus, it will be 8 years before the requirements of the Nitrate Directive are fully implemented. A review of the vulnerable zones will then occur every 3 years to account for any changes that may affect their designation, such as changes in livestock density.

The Directive has several provisions intended to reduce the leaching and runoff of nitrate from manure. Though these will have to be further clarified, they include periods when manure may be applied, regulation of manure application to waterlogged, sloping, flooded, frozen, or snow-covered ground, consideration of rainfall, and provision for manure storage facilities.

The Directive states that nitrogen from livestock manure may not exceed 170 kg/ha, after the 8-year period of transition. However, the Directive also adjusts the application of livestock manure for the use of nitrogen by crops, the amount of nitrogen from commercial fertilizer, and other sources, and the amount of nitrogen in the soil. Therefore, the 170 kg/ha may be viewed as a maximum annual residual (MAR) of nitrogen. The MAR thus includes nitrogen from both manure and commercial fertilizer, less uptake by crops.

Reduction of Residual Nitrogen

The programs ultimately implemented by countries under the Nitrate Directive will no doubt stress ways of handling and disposing of manure. However, the effect of such methods on nitrogen delivery to the soil are difficult to quantify at present. Therefore, for the purpose of analysis, residual nitrogen is viewed as being reduced either by restricting the amounts of fertilizer use or the application of manure.

The Directive is more likely to focus on restricting the application of manure, however, than on the use of fertilizer. Fertilizer is the primary source of nitrogen for crops because it may be economically pelleted, transported, and applied at optimum times during the growing season. Farmers have also become more prudent in applying fertilizer in ways that increase the proportion actually utilized by crops (Follott and coauthors).

On the other hand, livestock manure is often not applied with the same goal of efficiency as fertilizer because manure is usually viewed as a costly waste. Part of the reason for this is the relatively high costs involved in handling and processing manure in ways that can economically maximize its contribution to soil fertility. Even with manure widely available, fertilizer use has increased significantly. Between 1960 and 1990, nitrogen use per hectare more than tripled, from about 30 kg to about 100 kg, while grain yields roughly doubled to 6 tons (fig. 2).

Calculation of Residual Nitrogen in EC Countries

Residual nitrogen levels are calculated for each EC country for 1986, using coefficients measuring the nitrogen content of various crops and types of manure (table 3), published in a more aggregate study by Koopmans. Countries where residual nitrogen levels exceed the MAR are then identified, and the reduction in livestock production and fertilizer use needed to reduce residual nitrogen levels to the MAR are calculated.

Nitrogen uptake by crops is computed by applying the coefficients in table 3 to crop production data from (Commission of the European Communities, 1988). The uptake by straw is calculated using a proportionality function from Koopmans.

The calculation of uptake by forage is complicated by the many different kinds of forage, which include different hays, pastures, and silage. This calculation is important because about one-half of UAA is planted to forage. Aggregate estimates of nonmarketable forage from Commission of the European Communities, 1988, were apportioned to the individual countries on the basis of the number of cattle and sheep (in terms of cattle units). Although strictly defined only for grass, the nitrogen coefficient from table 3 was applied to these estimates of forage in each country.

The estimated amounts of nitrogen from commercial fertilizers, and the uptake by crops are presented in table 4. About 9.5 percent of the nitrogen applied in the form of fertilizer in the EC is in excess of what is needed by crops. The Netherlands has the largest percentage residual, relative to use, while Belgium, Ireland, and Italy have a deficit.

Aggregate data do conceal the concentration of nitrogen, however, with the possible exception of small countries such as Denmark, Belgium, and The Netherlands. For example, most fertilizer is not applied to forage. Therefore, most of the residual nitrogen is concentrated on crop acreage. Within each country, this residual tends to be concentrated where relatively little forage and large amounts of crops are grown.

Figure 2

EC-10 fertilizer nitrogen rate and grain yield

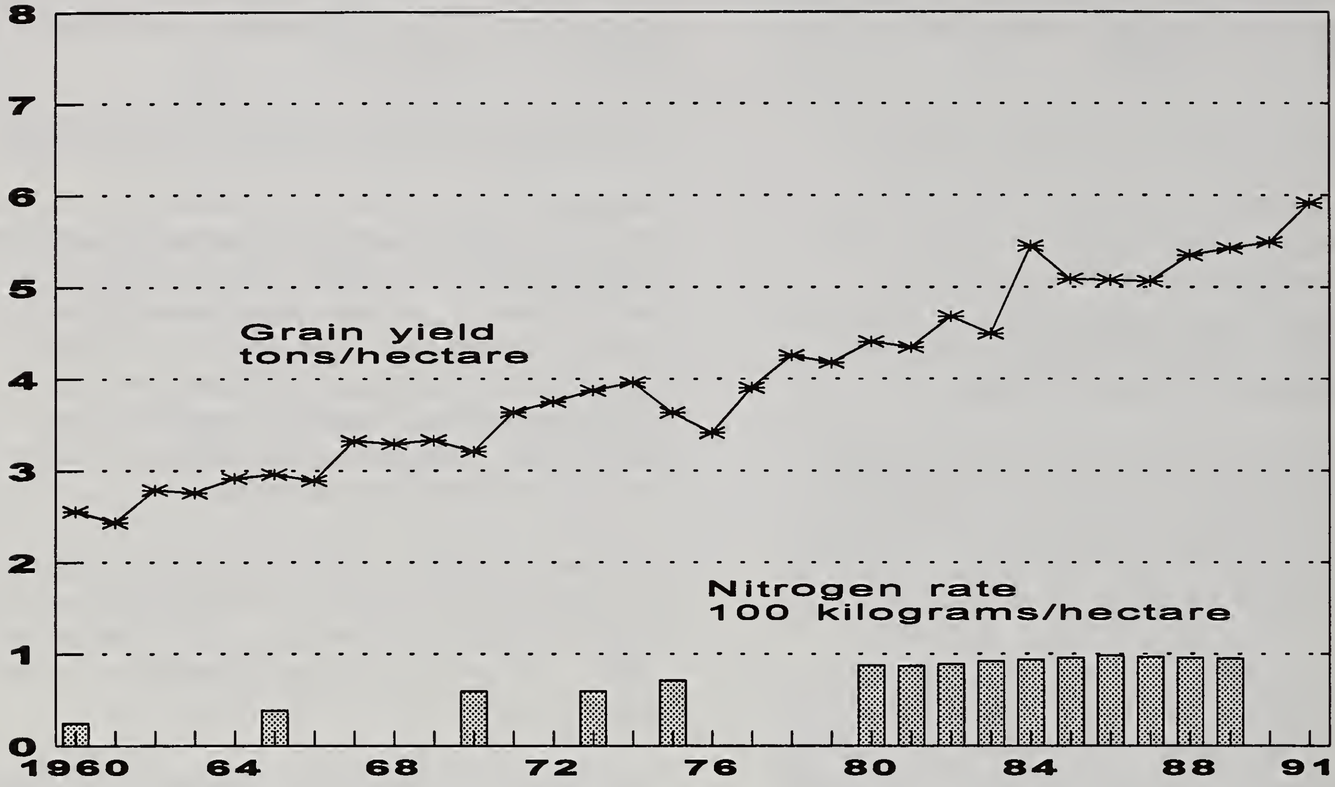


Table 3—Nitrogen content of selected commodities

	Wheat	Rice	Coarse grains	Grass	Cattle	Pigs	Poultry	Sheep
	Percent				*Kilograms/animal/year*			
Nitrogen content	1.9	1.3	1.5	3.0	64	13	.48	20

Source: Koopmans.

Table 4—Nitrogen fertilizer use and uptake, EC-10, 1986

	Uptake							
	Wheat	Coarse grains	Straw	Rice	Forage	Total	Use	Residual
	Million metric tons							
Belgium[1]	.03	.02	.01	0	.16	.21	.20	-.01
Denmark	.04	.09	.03	0	.13	.29	.38	.09
Germany	.20	.23	.11	0	.78	1.31	1.58	.26
Greece	.05	.04	.02	*	.29	.40	.43	.03
France	.51	.35	.21	*	1.34	2.41	2.57	.16
Ireland	*	.02	*	0	.37	.41	.34	-.06
Italy	.02	.13	.08	.01	.63	1.03	1.01	-.02
Netherlands	0	*	*	0	.26	.28	.50	.22
United Kingdom	.26	.16	.11	0	1.00	1.52	1.67	.15
Total	1.28	1.04	.58	.02	4.95	7.86	8.69	.83

[1]Contains a small amount for Luxembourg.
* = Less than 0.01 million tons.

About one-half of nitrogen from manure comes from cattle, although this varies from a low of 10 percent in Greece to 69 percent in Ireland (table 5). Pigs dominate as the source of nitrogen only in Denmark, although they are a major source in Belgium and The Netherlands. Sheep are a significant source of nitrogen in all countries except Belgium, Denmark, Germany, and The Netherlands, but predominate only in Greece. Most of the nitrogen from poultry manure is concentrated in France and the United Kingdom.

The total amount of nitrogen from livestock manure is nearly twice the amount of calculated uptake from forage. Therefore, for many countries, even if the uptake from forage is underestimated, the addition of manure may add an amount of nitrogen in excess of what can be absorbed by crops.

For the EC as a whole, nearly 10 percent of the 8.7 million tons of nitrogen from commercial fertilizer use is residual (table 4). An additional 9.6 million tons of nitrogen from livestock manure must, therefore, be accommodated (table 5). For Denmark and The Netherlands, the amount of residual nitrogen from fertilizer alone is 25 and 44 percent, respectively. The Netherlands must also accommodate an amount of nitrogen from manure that is 1.5 times the amount from fertilizer.

Reductions in Livestock Numbers

Of the total nitrogen applied in the EC, 57 percent is residual (table 6). Nearly two-thirds of the 10.5 million tons of residual nitrogen that enters the soil from agricultural sources in the EC is located in Germany, France, and the United Kingdom. Only 18 percent of the residual nitrogen is found in Belgium, Denmark, and The Netherlands.

Residual nitrogen as a percentage of total nitrogen applied varies from 52 percent in France to 77 percent in The Netherlands. Belgium, Denmark, and The Netherlands have the highest residual nitrogen levels, equal to 64 percent, 65 percent, and 77 percent, respectively. These are also the only three countries that exceed the MAR of 170 kg/ha. Belgium, Denmark, and The Netherlands have residual amounts of nitrogen of 240 kg/ha, 187 kg/ha, and 480 kg/ha, respectively.

In order to achieve the MAR, residual nitrogen for Belgium, Denmark, and The Netherlands would have to be reduced by 29 percent, 9 percent, and 65 percent, respectively (table 7), and imply tonnage reductions of 107,000, 47,600, and 632,000. These tonnages are equivalent to reductions in total nitrogen from livestock manure of 28 percent, 11 percent, and 84 percent, respectively. Reductions of this size, in livestock numbers, may be politically difficult to achieve, however, and imply the need for manure management schemes and reductions in fertilizer use.

In order to provide a benchmark by which to evaluate the Nitrate Directive, possible percentage declines in livestock numbers are calculated to be no larger than the required percentage declines in residual nitrogen. This rule allows most of the burden of reducing residual nitrogen to remain with livestock, as the Directive intends. The 107,000-ton decline in residual nitrogen for Belgium may therefore be achieved with a 28-percent reduction in livestock numbers and no decline in fertilizer. For Denmark, the 47,600-ton residual may satisfied with the maximum 9-percent reduction in livestock numbers and a 2.2 percent decrease in fertilizer use. Similarly, residual nitrogen may be reduced to the MAR for The Netherlands with decreases in livestock numbers and fertilizer use of 65 percent and 28 percent, respectively.

The reductions in livestock numbers are still quite significant even when fertilizer use is reduced, especially, in The Netherlands. They are much more moderate when viewed on an EC-wide basis, however (table 8). Pig production is reduced the most, at 11.7 percent, followed by a 10-percent reduction in egg and broiler numbers. Dairy and beef numbers are reduced by 7.8 and 4.8 percent, respectively. Sheep numbers are reduced by less than 1 percent because relatively few sheep are raised in the three countries affected by the Nitrate Directive.

Effects on exports of Livestock Products

The Nitrate Directive may have significant effects upon the exports of livestock products, assuming declines in self-sufficiency proportionate to the reductions in livestock numbers (table 9). The effects are especially significant for Belgium and The Netherlands because livestock numbers may decline rather significantly under the Directive. Belgium becomes less than 100-percent self-sufficient in butter and poultry products, while The Netherlands becomes less than self-sufficient in beef and veal, butter, dry (skim) milk, pork, and poultry meat.

Table 5—Sources of nitrogen from manure, EC-10, 1986[1]

	Dairy	Beef	Pigs	Layers	Broilers	Sheep	Total[2]
				1,000 metric tons			
Belgium[3]	65	137	122	5	41	10	381
Denmark	58	109	224	2	40	1	435
Germany	349	651	549	25	102	42	1,717
Greece	14	36	33	8	32	332	455
France	416	1,043	275	33	299	327	2,393
Ireland	98	272	30	2	15	120	536
Italy	197	380	154	23	138	265	1,157
Netherlands	149	176	249	19	143	16	752
United Kingdom	208	604	217	25	254	511	1,819
Total	1,555	3,408	1,851	142	1,064	1,625	9,645

[1] Numbers may not sum to totals because of rounding.
[2] Livestock numbers from Commission of the European Communities, 1988 are multiplied by the coefficients in table 1. Beginning inventories are used for cattle; number slaughtered are used for pigs and sheep, with 7 percent and 50 percent being added to account for the breeding herd; the number of eggs hatched for chick placement, for eggs, and for meat are used for layers and broilers.
[3] Contains a small amount for Luxembourg.

Table 6—Nitrogen applied, uptake, and residual, EC-10, 1986

	Applied				Residual		
	Livestock	Fertilizer	Total	Uptake			
	1,000 metric tons					*Percent*	*Kilograms per hectare*
Belgium[1]	382	199	580	211	369	64	240
Denmark	434	381	816	287	529	65	187
Germany	1,717	1,578	3,295	1,314	1,981	60	165
Greece	455	432	887	403	484	55	84
France	2,393	2,568	4,961	2,406	2,555	52	81
Ireland	536	343	879	407	473	54	83
Italy	1,157	1,011	2,167	1,027	1,140	53	65
Netherlands	752	504	1,255	284	972	77	480
United Kingdom	1,819	1,671	3,490	1,521	1,969	56	106
Total	9,645	8,688	18,333	7,860	10,473	57	108

[1]Contains a small amount for Luxembourg.

Table 7—Reductions in residual nitrogen, livestock, and fertilizer use to achieve the MAR

Country	Residual nitrogen	Only livestock	Livestock and fertilizer: Livestock	Livestock and fertilizer: Fertilizer
	Metric tons	*Percent*		
Belgium	107,000	28	28	0
Denmark	47,600	11	9	2.2
Netherlands	632,000	84	65	28.0

Table 8-Reduction in EC-10 livestock to achieve MAR

Dairy	Beef	Pigs	Layers	Broilers	Sheep
		Percent			
7.8	4.8	11.7	10.1	10.1	.91

Table 9—Self-sufficiency: 1991-92 average and estimated under the Nitrate Directive[1]

Country	Beef and veal	Butter	Cheese	Dry milk	Pork	Poultry meat	Eggs
				Percent			
Belgium:[2]							
1991-92	149	124	35	182	176	115	126
Estimated	107	89	25	131	127	83	91
Denmark:							
1991-92	197	188	368	120	373	216	103
Estimated	179	171	335	109	339	197	94
Netherlands:							
1991-92	194	174	294	27	257	205	339
Estimated	68	61	103	9	90	72	119
EC-10:							
1991-92	110	111	109	132	105	108	102
Estimated	105	102	100	121	93	97	92

[1]The estimated effects of the Directive on self-sufficiency are calculated by applying the 1986 reductions in livestock numbers to the self-sufficiency rates for 1991-92.
[2] Contains a small amount for Luxembourg.

At the EC-10 level, self-sufficiency drops below 100 percent for pork and poultry products and to 100 percent for cheese. The declines in self-sufficiency for the EC-10, nevertheless, imply rather significant declines in exports. For example, they imply that beef exports decline by 50 percent and dairy products decline between 34 percent and 100 percent. For pork and poultry products, the EC would actually become a net importer.

Recent Changes in Livestock and Nitrate Levels

A number of policy developments have occurred in the EC in the past decade that might have reduced the input of nitrogen from livestock and crops. Reductions in price support and intervention buying for grain have occurred since the early 1980's. More recently, an acreage set-aside program has been established for grain. Beginning in 1984, milk produced beyond quota was charged a superlevy equal to 75 percent of the target price. This superlevy has since been increased to 115 percent of the target price.

The acreage set-aside and decreases in price supports have not reduced the production of grain in any EC country. Yields are likely to increase from new varieties of grain, leading to higher intensification on a slightly reduced area planted. Fertilizer use has remained about constant over the last several years.

The dairy quota has reduced dairy cattle numbers and influenced the composition of the cattle herd. Between 1986 and 1991, dairy cattle numbers decreased by 12.5 percent in Belgium, 15 percent in Denmark, 17.8 percent in The Netherlands, and 13 percent in the other EC countries. While the cattle cycle has not yet fully responded to the dairy quota, beef numbers have not declined as much as dairy (except for Belgium). Beef cattle decreased by 1.75 percent in the EC and by 13.9 percent in Denmark. In Belgium and The Netherlands, beef cattle increased by 16 percent and 6.2 percent between 1986 and 1991, respectively.

Table 10—Nitrate in manure, 1986 and 1991

Country	1986 base	1991
	1,000 tons	
Belgium	381	402
Denmark	435	422
Netherlands	752	781
Other	8,087	8,209
Total EC	9,655	9,814

If other livestock had decreased by the same proportion as dairy, progress would have been made toward achieving the goals of the Nitrate Directive. This was not generally the case in most countries, however. Therefore, the amount of nitrate in manure increased slightly between 1986 and 1991 for all countries except Denmark (table 10). Nitrate levels in manure decreased by nearly 3 percent for Denmark. For Belgium and The Netherlands, nitrate levels increased by 5.5 and 3.8 percent, respectively.

Conclusions and Limitations

Nitrate pollution is a significant and growing problem in parts of the EC. Measurements of nitrate in surface and groundwater may underestimate the problem because it can take decades for nitrate to reach the water. Nitrogen balance tables that subtract nitrogen used by crops from the amounts applied in the form of fertilizer and manure may give better estimates of the amount of residual nitrogen currently being applied.

The Nitrate Directive implies possible reductions in EC livestock production ranging from 1 percent for sheep to 12 percent for pigs. Reductions may occur only in Belgium, Denmark, and The Netherlands, but are subject to many factors that are unknown or difficult to account for at present. Smaller reductions are likely to the extent that manure is more carefully stored, handled, and applied, or substituted for commercial fertilizer. Livestock may also be fed differently or raised in regions of other countries where problems do not exist. A system of taxes and/subsidies may be necessary to bring about some of these changes, however.

Aggregate measures of residual nitrogen do not reveal problems known to exist in certain parts of the United Kingdom, France, Germany, and northern Italy. Therefore, some reduction in livestock numbers may be required in these countries except to the extent that production shifts to other regions as a result of policy inducements or economic pressures associated with the Nitrate Directive.

Some technical relationships that affect nitrogen balance need to be refined in future research to provide more reliable estimates of livestock reduction. Most importantly, subregional analysis is needed because aggregation hides problems in large countries, although it is probably not too misleading for small countries such as Belgium, Denmark, and The Netherlands. Account also needs to be taken of nonagricultural sources of nitrogen, such as acid rain or the decay of trees and vegetation. More work also needs to be done to establish the reliability of the nitrogen content coefficients. Finally, the dynamics and accuracy of the nitrogen cycle needs to be improved.

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Chapter 12

Assessing Environmental and Agricultural Policy Linkages in the European Community

Stephen Haley

The European Community (EC) is addressing agriculture's contribution to environmental degradation, even while undertaking major reform of many of its agricultural policies. Reduction in livestock numbers, resulting from the EC Nitrate Directive, should offset the cost reduction effects of lower domestic feedgrain prices implied by EC agricultural policy reform. Because there is less domestic demand for feed, net EC grain exports will not be reduced as much as implied by the reform measures alone. Although not planned, fertilizer taxes could be effective in reducing residual nitrate levels without adversely affecting production, although targeting of the taxes to areas within countries with high nitrate levels could make them even more effective. Agricultural policy reform implies beneficial environmental effects, but most improvements result from the EC set-aside program rather than decreased demand for fertilizers resulting from reduced price incentives to produce.

Introduction

Until recently, there has not been strong interest in the relationship between environmental and agricultural policies in the European Community (EC). In the past, environmental policies have been typically in the domain of national and provincial governments, reflecting the local, particularized character of environmental problems. Agricultural policies, on the other hand, have emphasized common, EC-wide, concerns of food security, rural development, preservation of rural character, and responsiveness to the demands of rural-based interest groups, especially farmers.

There is now an increasing recognition of agriculture's contribution to environmental degradation (Agra Europe, 1991; Vocke, 1991). One of the chief concerns is the effect of nitrate accumulation on water quality. Nitrates from livestock manure and chemical fertilizers are leached from the soil and lead to the contamination of potable water supplies in several highly populated areas of the EC and to the eutrophication of EC inland and coastal waters. The problem is considered sufficiently serious and transnational in character to require an EC-wide approach.

This paper presents two aspects of the trade/environmental interface. First, there is the effect of agricultural policy reform on the EC's level of fertilizer use and on the level of manure from livestock production. Specific policy implications of the "MacSharry Plan" for EC agriculture and the environment will be described. A goal is to study the compatibility of trade and/or production policy reform with the pursuit of environmental objectives. Second, this paper examines the effect of environmental policy measures on agricultural production and trade. The policies include provisions of the EC Nitrate Directive (especially regarding livestock density restrictions) and a hypothetical tax on nitrogen fertilizer use. The effect of these environmental policies can be traced through to world markets and to U.S. agriculture.

Nitrate Pollution in the EC

Nitrate pollution has been identified as a major problem in the EC. Many policymakers are now concerned about the effect of animal manures and fertilizer use on water quality. In many areas of the EC, public water supplies cannot meet the EC standard for potable water of 50 milligrams (mg) of nitrate per litre. Vocke (1991) has identified areas where the problem is particularly severe: The Netherlands, low-lying parts of Belgium and France (especially Brittany), southern Britain, Denmark, much of Germany (especially Lower Saxony and former East Germany), and northern Italy. Vocke argues that the major threat to water supplies for human consumption stems from the widespread introduction of intensive livestock confinement production in the 1960's and its subsequent rapid growth. Health risks are associated with methemoglobinemia or "blue baby" syndrome. This dangerous condition is caused by oxygen starvation in bottle-fed infants. There are also fears that high concentrations of nitrates

contribute to the incidence of stomach cancer, although the connection is unproven.

Nitrate pollution has also contributed to the eutrophication of EC inland and coastal waters. Nitrates from animal manures and nitrogen fertilizer, applied to crops, are responsible for this problem. The leached nitrates promote the growth of algae, whose decay depletes oxygen levels, especially in marine waters. (Phosphates are considered more of a problem than nitrates for freshwater eutrophication.)

EC agricultural policies have contributed to the nitrate problem. The EC's Common Agricultural Policy (CAP) has encouraged the growth of livestock and crop production through guaranteed, high, domestic prices, exceeding world levels and divorced from world price trends and disturbances. High returns from agricultural activities have been capitalized into high land prices that have, in turn, favored intensive, land-saving livestock and cropping technologies. These technologies have been largely responsible for excess nitrates in the environment.

Although environmental problems extend throughout the whole of the EC, environmental damage from nitrate pollution is more of a localized problem, concentrated especially in the areas listed above. Leaching risks are considered the most serious during periods of high rainfall, low evaporation, and low crop nitrogen demands: that is, usually during the fall. Optimal policy measures would, ideally, be targeted to those areas where the problems are the most serious and would take account of seasonal influences. Also complicating remedial policy measures is the dynamic nature of nitrate pollution. It can take up to 40 years for nitrates to travel from the soil to groundwater. Travel time is largely a function of intervening rock layers (Hanley, 1990).

Potential Policy Responses

Potential policy options can be categorized into three areas: reduction in nitrogen fertilizer applications, reduction in animal manure applications, and better management of nitrate applications (Hanley, 1990). One way to reduce fertilizer applications is through taxing their use. Hanley reports, however, that most estimates of fertilizer demand show it to be inelastic, implying that high tax rates would be needed to achieve sizeable reductions. Also, the localized nature of the nitrate problem would imply differentiated tax rates, although transaction costs could be high. A uniform tax would be simpler administratively, although potentially unfair. A headage tax on livestock producers could be used to internalize costs of manure disposal. Other solutions could be based on tradeable nitrogen quotas, or lump-sum compensation of producers subject to the nitrogen/headage taxes.

Increased regulation of land use is another possibility. Regulations covering land in vulnerable zones could be used to control detrimental management and to encourage the adaption of better schemes. Regulations could be enacted to limit nitrogen applications in the fall and/or encourage the planting of fall cover crops. Regulations could limit the application of manure during periods of heavy rainfall and low crop growth. Policies could encourage the construction of manure storage facilities, the transport of manure to other areas, and/or the reduction of concentrations of livestock. Laws could restrict the large-scale ploughing of pastureland.

Although not primarily directed at environmental problems, CAP Reform (the "MacSharry Plan") could promote lower net deliveries of nitrates to the environment. An aim of the program is to move away from supporting markets and toward supporting landholders (Agra Europe, 1991). Reduction of producer prices of cereals by 30 percent would translate into lower land prices, thereby encouraging more extensive agricultural techniques that use less yield-enhancing fertilizer. Although cattle prices would be reduced by only 15 percent, decreased profitability could lead to fewer head and consequently less manure, all else constant.[1] The land set-aside provisions (the idling of 15 percent of arable land on holdings above 20 hectares) could be useful in switching from arable crop production to grasslands or woodlands in vulnerable areas. Hanley (1990) reports that most environmental research does not predict significant nitrate abatement from policies oriented toward output, but the effect on nitrate deliveries of the MacSharry Plan deserves attention because of the magnitude of the proposed price changes and the set-aside provisions.

The Nitrate Directive

The EC Nitrate Directive was passed by the Council of Environmental Ministers on June 14, 1991. Its intent is to limit nitrate levels in potable

[1]Lower grain prices imply lower feed costs, possibly offsetting the effect of lower cattle prices.

Analytical Framework

For purposes of this analysis, the SWOPSIM framework was revised to include an EC fertilizer sector. Changes in crop supplies due to changes in fertilizer prices are driven by calculated fertilizer price elasticities in the crop supply equations. The calculation of the elasticities depends on the cost share of nitrogen fertilizers in crop production and the size of that crop's own price supply elasticity. The sizes of these calculated elasticities are small: -.04 for wheat; -.03 for corn; -.06 for other coarse grains; and -.05 for soybeans. The implication of the small sizes is that, a priori, one should expect relatively small crop-supply changes resulting from the taxation of fertilizer use.

Although the calculation methodology is useful for revising the model without much effort, additional research could be directed to estimating the effect of reduced fertilizer usage on crop yields for individual EC countries or regions within EC countries. This information must be tied to estimates of reduced incentives to use fertilizer as its price increases due to taxation.

water to less than 50 mg per liter. It is not part of the MacSharry Plan and many of its details have yet to be worked out (Leuck, 1993).

The Directive requires EC member countries to designate "vulnerable" zones where water standards are not being met. The countries are to develop "codes of good practice" that are mandatory in vulnerable zones and voluntary, elsewhere. Implementation of the Directive is to take place over an 8-year timeframe. One known limitation is that the application of livestock manure can be no more than 170 kg per hectare at the end of the 8-year period. A further restriction, although not clearly spelled out, is that the application of manure must be consistent with good agricultural practice in relation to use of nitrogen by crop, the amount of nitrogen from chemical fertilizers and other sources, and the amount already in the soil. The application rate may, therefore, be less than the prescribed maximum.

Analytical Framework and Scenario Description

The model chosen for this analysis is the Static World Policy Simulation (SWOPSIM) model developed at the Economic Research Service (ERS) to analyze the implications of worldwide agricultural trade liberalization (See Box 1). An advantage of using SWOPSIM is that it is a relatively well-known modeling framework. It has been extensively documented (Roningen, Sullivan, and Dixit, 1991), and the modeling software and databases have been distributed widely around the world. A drawback is that limitations associated with the SWOPSIM framework (for instance: static framework, constant elasticity specification, presumed lack of policy detail, and so forth), are carried over to this study.

Two sets of policy changes are examined using SWOPSIM. The first set encompasses the EC CAP reforms, sometimes referred to as the "MacSharry Plan." The second set of policy changes are designed to achieve environmental objectives. There are two specific scenarios. The first is the adaption of the EC Nitrate Directive. The modeling emphasizes the effects of the Directive on livestock densities. The second deals with the imposition of a hypothetical tax on the use of nitrogen fertilizers. Results from the fertilizer tax scenarios provide a standard of comparison of effects from the CAP Reform and Nitrate Directive scenarios, especially regarding reduced nitrate deliveries. The fertilizer tax, however, may not be a preferred EC environmental policy because it may not reduce nitrate deliveries sufficiently in areas (described above) where nitrate pollution is considered most severe.

MacSharry Plan

There have been several versions of the MacSharry Plan. The version used in this analysis is the one planned for implementation over 3 years starting in 1993/94 (Madell, 1992). The specific features modeled are as follows:

- Price supports are reduced:
  - grains intervention prices cut 30 percent
  - oilseed support prices cut 50 percent
  - beef intervention price cut 15 percent
  - commodities not covered include cotton, rice, and sugar
- Compensation for price reductions made through direct payments:
  - 45 ecu/mt for grains
  - 152 ecu/mt for oilseeds

- Payment based on historic yields/herd size and require current production
- Larger farmers required to set aside 15 percent of arable crop base

Unlike the U.S. program, the EC set-aside is not commodity specific and small farmers are exempt. Estimates of how much land will be set-aside and how specific crop acreage will be affected must be exogenously incorporated into the model. For this study, estimates made (but not published) by the European Branch of the Agriculture and Trade Analysis Division (ATAD) of ERS were used. These estimates of individual commodity land area reductions are as follows: wheat: -7 percent; corn: -9 percent; other coarse grains: -12 percent; soybeans and other oilseeds: -12 percent.

An important question for modelers of EC CAP Reform is what effect the direct payments meant to compensate producers for support price reductions and land set-asides will have on production. According to plan, producers will be paid a subsidy derived from a "base area" of cereals that includes set-aside acreage (Agra Europe, 1993). The base area is the area devoted to cereal production and the set-aside in the crop years 1989, 1990, or 1991. This scheme implies that production beyond the 1991 level will not be subsidized. Although some modelers have questioned this assumption (Abler and Shortle, 1992), this paper assumes that compensatory income payments will have no effect on EC crop production.

EC Nitrate Directive

Many of the provisions of the EC Nitrate Directive have yet to be worked out. The paper by Leuck in this volume has examined the likely effects of the Directive on livestock supplies in individual EC countries. The bulk of the livestock reductions occur in Belgium (28 percent relative to a 1986 base), Denmark (9 percent relative to the base), and The Netherlands (65 percent relative to the base). On an EC-wide basis, the reductions appear more modest: beef, -4.8 percent; pork, -11.7 percent; mutton/lamb, -.9 percent; poultry, -10.1 percent; eggs, -10.1 percent; and dairy, -7.8 percent.[2]

Because the Directive will be implemented along with EC CAP reform, this scenario will be run, assuming that the changes described above (MacSharry Plan scenario) are occurring simultaneously. An implication is that the EC-wide livestock reductions will not be as great as implied by Leuck's analysis. The reason is that feedgrain costs are to be significantly reduced under the terms of CAP Reform. Although the reductions in Belgium, Denmark, and The Netherlands will be bound by the Nitrate Directive, lower feedgrain costs should expand livestock production elsewhere in the EC (except perhaps beef, whose post-reform intervention price will be 15 percent lower).

Nitrogen Fertilizer Tax

Although it is not planned, the EC could choose to impose a tax on the use of nitrogen fertilizer to reduce the delivery of nitrates to the soil. As alluded to previously, a uniform EC-wide nitrogen fertilizer tax is not likely to sufficiently reduce residual nitrate levels in regions where nitrate accumulations are deemed the most severe. Fertilizer taxes selectively applied on a national or regional level would likely be more effective in reducing nitrate deliveries, especially if applied in conjunction with the livestock density restrictions described by Leuck. At present, the modeling structure of the SWOPSIM model is not sufficiently disaggregated to run this type of scenario. A feasible modeling alternative is to analyze the consequences of an EC-wide nitrogen fertilizer tax in order to provide a standard of comparison to the results of the other modeling scenarios described above. This scenario would be instructive in predicting the cumulative effect of more optimally placed taxes on aggregate EC agricultural production and trade, and on world prices. For purposes of this paper, a tax rate of 75 percent is chosen.[3]

Effect of Policy Changes on Production, Trade, and World Prices

Table 1 shows base values for EC agricultural production and net trade, as well as world prices for the listed products/ commodities. With the exception of soybeans, the EC is a large producer

[2]See table 8 of Leuck's article in this volume. Leuck also notes that during the period 1986 to 1991, nitrate levels from livestock manure increased by 5.5 percent in Belgium and 3.8 percent in The Netherlands, although they declined by 3 percent in Denmark. Because the model's base year is 1986, these changes are not reflected in modeling scenarios.

[3]The longer version of this paper, as well as a paper by Gunasekara and coauthors (1992), analyzes the implications of a 50-percent tax rate, as well as the 75-percent rate. In this paper it is assumed that fertilizer demand is relatively inelastic with respect to its price: -0.5 (Burrell, 1989). Fertilizer supply is assumed to be perfectly elastic. See the longer version of this paper for a modification of this assumption.

Table 1—Base year (1986) EC quantity and price data

Product/commodity	EC production	EC trade	World price
	------------*1,000 metric tons*	------------	*Dollars per metric ton*
Beef	7,983	715	2,091
Pork	11,517	174	2,341
Poultry meat	5,413	298	1,083
Poultry eggs	4,845	88	2,145
Butter	2,175	196	2,048
Cheese	4,057	216	2,744
Milk powder	2,302	255	1,984
Wheat	71,688	14,167	115
Corn	24,974	-2,127	87
Other coarse grains	56,288	6,022	82
Soybeans	903	-13,211	208
Other oilseeds	7,462	-1,670	324

of all the listed goods.[4] Also, trade constitutes an important outlet for EC production: over 20 percent of wheat production is exported, followed by other coarse grains (11 percent), milk powder (11 percent), beef (9 percent), butter (9 percent), and so on.

Tables 2, 3, and 4 show modeling results with respect to production, trade, and world prices for the MacSharry Plan, the Nitrate Directive, and the fertilizer tax scenarios, respectively. Table 5 shows the effect on the levels of U.S. agricultural net trade.

MacSharry Plan

Results indicate about a 15-percent reduction in crop production due to the MacSharry reforms.[5] The intervention price cuts and the land set-asides contribute about equally to the production decline; that is, if the set-aside program were put into place without the intervention price reductions, aggregate production would decrease about 8.2 percent.

Lower grain prices contribute to the expansion of production of pork (over 8 percent), poultry meat (over 5 percent), and poultry eggs (over 4 percent), and mitigate the decline in beef production due to the cut in its intervention price by about 0.6 percent. Pork exports, which were small in the base (1.5 percent of production), increase significantly to about 8 percent of production. Poultry meat and egg exports more than double.

Lower EC grain production and increased domestic demand by the EC livestock sector causes net exports of wheat to drop by nearly 80 percent and corn imports to increase by over 300 percent. Additionally, the EC becomes a net importer of other coarse grains instead of being a large exporter. World grain prices increase in response to increased EC excess demand: over 12 percent for wheat, 6 percent for corn, and over 15 percent for other coarse grains.

U.S. grain exports (wheat, corn, and other coarse grains) increase from 73.3 million metric tons (mmt) to 81.2 mmt, a 10.8- percent volume increase. U.S. export revenue attributable to grain and oilseed exports increases from $12.8 to $14.7 billion, or about 15 percent. However, except for beef, U.S. livestock exports are adversely affected: pork imports increase by almost double, poultry meat exports decline by over 40 percent, and U.S. poultry eggs exports disappear. Net expenditure on livestock imports increases from $1.9 to $2.3 billion. Nonetheless, total net agricultural export revenue (grains, oilseeds, and livestock products) increases almost 14 percent after CAP Reform is in place.

Nitrate Directive

The direct effect of the Nitrate Directive is to lower EC livestock production through the density

[4]The EC outproduces the United States with respect to the following products/commodities: pork, poultry eggs, the dairy products, wheat, other coarse grains, and oilseeds other than soybeans.

[5]Weights used to calculate aggregate crop volume changes are based on the volume proportion of each crop to the total: wheat -- .405, corn -- .141, other coarse grains -- .318, rice -- .007, soybeans -- .005, other oilseeds -- .042, and sugar -- .082.

Table 2—Changes in EC production and trade, and world prices: MacSharry proposal

Product/commodity	EC production	EC exports	EC imports	World price
	Percent change			
Beef	-7.15	-138.88	-	7.18
Pork	8.75	665.80	-	-3.37
Poultry meat	5.67	113.40	-	-.58
Poultry eggs	4.24	225.77	-	-1.39
Butter	-1.12	-30.32	-	5.50
Cheese	.76	14.05	-	-.55
Milk powder	-1.84	-15.78	-	1.73
Wheat	-12.64	-78.95	-	12.18
Corn	-17.63	-	314.67	6.14
Other coarse grains	-16.54	-223.12	-	15.54
Soybeans	-28.30	-	2.02	1.95
Other oilseeds	-39.47	-	173.81	14.42

- = Not applicable.

Table 3—Changes in EC production and trade, and world prices: Nitrate Directive

Product/commodity	EC production	EC exports	EC imports	World price
	Percent change			
Beef	-10.11	-174.11	-	9.65
Pork	-1.91	17.20	-	1.56
Poultry meat	-3.95	-51.03	-	3.02
Poultry eggs	-4.29	-221.16	-	3.62
Butter	-1.77	-37.35	-	7.65
Cheese	-.25	-4.14	-	3.03
Milk powder	-3.06	-26.62	-	5.32
Wheat	-12.66	-68.13	-	11.43
Corn	-17.52	-	243.43	7.67
Other coarse grains	-16.58	-177.60	-	14.54
Soybeans	-28.34	-	1.78	1.42
Other oilseeds	-39.50	-	173.59	13.85

- = Not applicable.

Table 4—Changes in EC production and trade, and world prices: 75-percent fertilizer tax

Product/commodity	EC production	EC exports	EC imports	World price
	Percent change			
Beef	-.00	-.10	-	.10
Pork	.02	3.20	-	.15
Poultry meat	.03	1.02	-	.19
Poultry eggs	.03	1.86	-	.13
Butter	-.00	-.02	-	-.11
Cheese	.00	-.01	-	.02
Milk powder	-.00	-.01	-	.06
Wheat	-2.19	-11.09	-	1.61
Corn	-1.66	-	19.70	.70
Other coarse grains	-3.27	-30.43	-	2.06
Soybeans	-1.67	-	.12	.17
Other oilseeds	-2.71	-	11.90	1.06

- = Not applicable.

Table 5—Effects on U.S. agricultural net trade

Product/commodity	Base	MacSharry	Nitrate Directive	75-percent fertilizer tax
		Net trade volume: 1,000 metric tons		
Beef	-739	-289	-153	-741
Pork	-470	-930	-502	-475
Poultry meat	276	159	398	279
Poultry eggs	64	-16	129	63
Butter	23	26	26	23
Cheese	-107	-113	-104	-107
Milk powder	300	303	303	300
Wheat	26,752	27,787	27,382	26,904
Corn	39,085	43,085	41,639	39,351
Other coarse grains	7,456	10,363	9,443	7,841
Soybeans	20,684	20,947	20,887	20,701
Other oilseeds	611	1,062	1,072	639
		Net trade revenue: Millions of dollars		
Livestock	-1,861	-2,254	-417	-1,878
Grain, oilseeds	12,798	14,685	14,209	12,984
Total	10,937	12,431	13,792	11,106

restrictions. Compared with the model base, beef production is 10 percent less, pork production is 2 percent less, poultry meat and egg production areboth about 4 percent less.[6] The density restrictions in Belgium, Denmark, and The Netherlands more than offset the cost reduction effects of lower feedgrain prices from CAP Reform in the rest of the EC. Also, EC livestock exports are reduced sufficiently to imply rises in the world prices of all modeled livestock products.

Although EC grain production is not much affected, the Directive does imply less domestic demand for feed. Therefore, net EC exports of wheat, corn, and other coarse grains are not reduced so much as indicated under CAP reform alone. In general, world grain and oilseed prices do not increase so much.[7] The implication for U.S. grain exports is that they do not increase as much. Compared to the MacSharry scenario, the growth in U.S. grain exports are 2.77 mmt less (wheat, 0.40 mmt less; corn, 1.45 mmt less; and other coarse grains, 0.92 mmt less).[8]

In spite of grain exports that do not increase as much as under CAP Reform alone, the United States benefits more as a consequence of the Nitrate Directive. Higher world livestock prices signal higher U.S. net exports of livestock products. The U.S. export revenue deficit from livestock trade decreases to $417 million. Although U.S. net export revenue from grains and oilseeds decreases relative to the MacSharry scenario, the decrease is more than offset by the livestock gains. The agricultural net export balance increases 26 percent relative to the base versus about 14 percent under the MacSharry Plan alone.

Fertilizer Tax

The 75-percent tax on nitrogen fertilizer use affects EC agricultural production relatively little in comparison to the other scenarios: Aggregate crop production is reduced by about 2.3 percent. The fertilizer tax implies small but not insignificant reductions in EC net exports of grains. Net wheat exports decrease about 11 percent, net corn imports increase by about 20 percent, and other coarse grain exports decrease by as much as 30 percent. World price increases are small: less

[6]It is possible that there would be an incentive to hold animals a longer period of time for fattening because of the density restrictions. In this case, meat production would not be as adversely affected as the change in livestock numbers might imply. This possibility is not pursued in this paper, although it is deserving of additional study.

[7]The price of corn is an exception. Growth in U.S. livestock production due to higher world livestock prices increases domestic demand for corn sufficiently to cause its world price to increase relative to the CAP Reform scenario (7.67 percent compared to 6.14 percent).

[8]The volume of U.S. grain exports is 7.1 percent higher than the base, which compares with 10.8 percent under CAP Reform alone.

than 2 percent in most cases. Effects on the EC livestock sector are minimal.

The United States is little affected by the EC fertilizer tax. Other coarse-grain exports from the United States may increase as much as 5 percent, and model results indicate about a 1.5 percent increase in U.S. agricultural net export revenue.

Effect of Policy Changes on the EC Nitrate Balance

Policies affecting EC agricultural output or input use are also likely to significantly affect the delivery of nitrates to the soil. The task is to obtaina quantitative assessment of the policy changes described in the modeling scenarios on nitrate deliveries. At this time it is not possible to relate the policy changes to actual improvement in water quality or some other environmental objective. Part of the problem, as alluded to previously, is the dynamic aspect of the accumulation of nitrates over time. Another problem lies in the aggregate EC-wide modeling approach. An examination of changes in the aggregate EC nitrate balance masks problems in specific regions within the EC. A better and feasible approach, but also more costly, would involve the construction of regionally focused components of the SWOPSIM model that would tie in to the other country/regions in the model.

This paper adapts the methodology of Koopmans (1987), who used IIASA's Basic Linked System to examine the delivery to the soil of nitrates and other nutrients. Koopmans' study used coefficients to calculate nitrogen from various livestock manures and the amounts of nitrogen retained in crops and grassland. He obtained the first set of coefficients from The Netherlands Ministry of Agriculture and the second from the Dutch food table and personal interviews. As Koopmans admits, the approach is probably only minimally satisfactory, given that coefficients for The Netherlands are applied to the EC as a whole. This weakness implies that less significance should be attached to nitrate levels shown in this report and more significance attached to a comparison among scenarios of changes in nitrate deliveries. Future, more disaggregated analysis would require greater precision in tracking nitrate deliveries.

Table 6 shows the calculation of the base EC nitrogen balance against which the scenarios can be compared. The first block shows nitrogen from livestock manure. Animal numbers are from the Food and Agriculture Organization (FAO). In the modeling scenarios, the percentage changes of meat production (for example, beef, pork, poultry) from the base are used to calculate new levels of nitrogen delivery.

The next block shows nitrogen fertilizer applied to crops and nitrogen stored in crops. The source of the fertilizer data for the SWOPSIM crops is the SPEL group (1989). FAO reports total nitrogen fertilizer use for the EC in 1986 at 9,900 thousand metric tons. The difference between this amount and the total for SWOPSIM crops is attributed to non-SWOPSIM crops (basically horticultural crops). Because these crops are not modeled, this amount is assumed not to change in any of the scenarios. The nitrogen percentage coefficient available for the SWOPSIM crops, except sugar beets, is used to calculate the nitrogen stored in the crops.

Although straw is not part of the model, it is calculated as a percentage of wheat production. Because coefficients are not available for the non-SWOPSIM crops, there is no accounting for how much nitrogen is stored in these crops.[9]

The last block shows the nitrogen in grass from EC pastureland. Permanent pasture land in hectares from FAO is multiplied by the grass coefficient to calculate the grass tonnage. This amount is multiplied by the nitrogen storage coefficient to calculate the nitrogen stored in the grass. Although pastureland is not tracked in SWOPSIM, there will be increases in pastureland resulting from the land set-aside portion of the MacSharry Plan. These land use changes have been estimated by ERS and have been described in a previous section.

Table 7 shows nitrogen balances implied by each of the scenarios. In addition, the MacSharry scenario is split into two components: the set-aside effect (no intervention price reductions) and the price effect (intervention price reductions but no EC set-asides).

MacSharry Plan

Modeling results imply that EC-wide nitrate deliveries could be reduced by 942 thousand metric tons. In terms of the components of the MacSharry Plan, the intervention price reductions

[9]Because there is no modeling of reduced fertilizer use by non-SWOPSIM crops, the reductions in nitrate deliveries described below are understated.

Table 6—Base EC nitrogen balance

Livestock	Number of head	Nitrogen manure coefficient	Nitrogen delivery
	Nitrogen from livestock manure		
	1,000	*Kilograms/ year/animal*	*1,000 metric tons*
Cattle	83,581	64	5,349
Pigs	95,707	13	1,244
Sheep	83,111	20	1,662
Poultry	794,000	.48	381
Total	-	-	8,636

Fertilizer application and nitrogen stored in crops

Crop	Nitrogen fertilizer use	Production	Nitrogen percentage coefficient	Nitrogen stored in crop
	---------1,000 metric tons---------			*1,000 metric tons*
Wheat	2,021	71,688	.019	1,362
Straw	-	-	-	680
Corn	441	24,974	.015	375
Other coarse grains	1,758	56,288	.015	844
Rice	31	1,275	.013	17
Soybeans	68	903	.006	5
Other oilseeds	478	7,462	.006	45
Sugar beets	367	14,415	-	-
Other	85	-	-	-
Non-ST86 crops	4,651	-	-	-
Total	9,900	-	-	3,328

Nitrogen in grassland

Item	Area	Grass coefficient	Nitrogen coefficient	Nitrogen in grass
	1,000 hectares	*Metric ton/hectare*		*1,000 metric tons*
Grassland	56,163	6.0663	.03	10,221

- = either not available or not applicable.

Table 7—EC nitrogen balance

Scenarios	Fertilizer application (+)	Livestock manure (+)	Nitrogen in crops (-)	Nitrogen in grass (-)	Net delivery
			1,000 metric tons		
Base	9,900	8,636	3,328	10,221	4,987
MacSharry	9,308	8,559	2,851	10,971	4,045
Components:					
Set-aside	9,598	8,636	3,055	10,971	4,208
Price	9,591	8,559	3,105	10,221	4,824
Nitrate directive	9,308	8,248	2,851	10,971	3,734
Fertilizer tax	8,524	8,636	3,248	10,221	3,691

do not reduce nitrate deliveries very much. Although nitrogen fertilizer use is reduced by 309 thousand metric tons, residual nitrates are only reduced by 86 thousand metric tons. This small reduction is based on the calculation that 223 thousand metric tons would have been retained in the crops that were not produced.

Nitrate deliveries from beef cattle manure are reduced by 245 thousand metric tons. However, this reduction is largely offset by increased nitrate deliveries from other livestock animal groupings that increase as a result of lower feed costs: 108 thousand metric tons from pigs, 39 thousand metric tons from sheep, and 22 thousand metric tons from poultry.

The set-aside component of the MacSharry Plan contributes the most to nitrate delivery reductions. The most important reason is that grass converted from cropland retains increased dumpings of manure from grazing livestock or mechanically spread by farmers. The additional nitrogen retention potential equals 750 thousand metric tons. A much smaller reduction of residual nitrates is due to reduced fertilizer use on set-aside land: 29 thousand metric tons.

Nitrate Directive

Reductions in EC livestock resulting from the Directive imply a decrease in EC-wide nitrate deliveries of 311 thousand metric tons. If livestock numbers drop in Belgium, Denmark, and The Netherlands, as much as indicated by Leuck's analysis, then total nitrate deliveries should drop in those countries by at least 513 thousand metric tons. This reduction implies that the rest of the EC could be faced with an additional 202 thousand metric tons of nitrate deliveries from new or expanded livestock operations. Whether this magnitude is capable by being absorbed (either technically or economically) must be evaluated by additional analysis. It is possible that areas not currently "vulnerable" could become so if the incentives to relocate livestock production, as predicted by the model, are, in fact, realistic.

Fertilizer Tax

The 75-percent nitrogen fertilizer tax reduces nitrate deliveries the most of all examined policy alternatives. However, because the tax is applied uniformly across the EC, it is doubtful that it reduces nitrate deliveries sufficiently in any particular vulnerable area. The bulk of the reductions are likely to be in areas of intensive crop production. Unless those areas happen to coincide with heavy concentrations of intensive livestock production, the reductions probably do not translate into strongly discernible environmental gains (such as cleaner water).

Conclusions

There is increasing overlap in environmental and agricultural policies. In the EC, policies dealing with nitrates and water quality (such as the Nitrate Directive) will likely affect agricultural production and trade patterns. Likewise, policies dealing with agricultural restructuring (like CAP Reform) will affect the rate of delivery of nitrates to the environment. This paper has attempted to estimate the magnitude of these effects.

Fertilizer taxes were shown to be effective in reducing residual nitrate levels, with only relatively small effects on EC production and trade patterns. However, this analysis was limited by considering only the application of a uniform tax rate (75 percent) across the entire EC. Targeting of the taxes, with rates perhaps higher than that used in this analysis, may be desirable to help achieve targeted nitrate reductions within particular regions of the EC. Additional attention could be focused on expanded use of organic fertilizers in targeted areas, which may be economically attractive because of the usual concentration of confinement livestock operations within problem areas.

CAP Reform under terms of the MacSharry Plan was shown to have moderately large production and trade effects. Environmental effects were shown to be substantial, but most resulted from the EC set-aside program rather than decreased demand for fertilizers resulting from reduced price incentives to produce. The set-aside program implies the conversion of cropland to pasture, which, in turn, implies greater extensification of livestock operations. Lower feed prices under the reformed CAP lead to an expansion of livestock production and consequent problems for animal waste disposal. Although the cut in the beef intervention price reduces the aggregate (or EC-wide) effect of this problem, certain areas may experience additional pressure to enact regulations regarding livestock operations.

The EC Nitrate Directive is an attempt to deal with nitrate problems from an EC-wide perspective. Although the ways in which it will be implemented are unclear at this time, it is likely, as indicated by

Leuck in his paper in this volume, to lead to large livestock reductions in Belgium, Denmark, and The Netherlands. Additional analysis based on more complete data sets of regional production patterns will be necessary, however. One trade implication of the Directive is that reductions in EC net grain exports will not be as great as predicted under terms of CAP Reform. Nonetheless, the implementation of the Directive over time may present the United States the opportunity to expand its share of world livestock trade as the EC share contracts.

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Chapter 13

Tropical Forest Policy and Trade: A Case Study of Malaysia

Mark Giordano

This chapter focuses on Malaysia, but takes the form of a case study of a sustainable agriculture issue. Malaysia possesses some of the largest tracts of tropical forest in the world, and is the world's largest exporter of both tropical logs and sawn timber. However, growing realization of the environmental degradation caused by deforestation, and a recognition that logging rates of past decades have been above those sustainable on a long-term basis, have prompted changes in both timber extraction and export policies.

Introduction

The world's tropical forests have received considerable attention in recent years as problems associated with deforestation have become better understood. Deforestation has been associated with numerous environmental problems, including: climatic change, biodiversity loss, and declines in agricultural productivity through soil degradation.[1] Analysis of the consequences of change in forest policy frequently focuses on direct, national, environmental and economic impacts, with less attention given to secondary and trade impacts. The purpose of this paper is to use the case of Malaysia to examine the linkages between tropical forest policy and trade.

Malaysia makes an interesting case study for a number of reasons. While other countries, including Brazil, Indonesia and Myanmar, have larger tropical forest reserves, Malaysia is the world's largest exporter of tropical hardwoods, suggesting that changes in Malaysian policy could have a large impact on global hardwood trade.[2] Due largely to land opened by deforestation, Malaysia has also emerged in the last decade as one of the world's largest exporters of cocoa and palm oil, the latter export in competition with U.S. soybean oil. The Malaysian case thus illustrates the potential link between forest sector policies and global trade in other agricultural-based commodities. Finally, Malaysia is a useful case study because of recent policy steps taken by its Government to control deforestation.

[1]World Resources 1992-93, pp. 118-119.
[2]AGROSTAT.

Growth and Structure of the Timber Sector

The Southeast Asian nation of Malaysia is made up of two geographically, and, to some degree, politically detached regions. West or Peninsular Malaysia borders Thailand and Singapore and possesses the seat of the national government, while insular East Malaysia, made up of the States of Sabah and Sarawak, shares the island of Borneo with Indonesia and Brunei. The climate and locations of both regions, just north of the equator, are ideally suited for the production of tropical timber.

Timber and forest products play an important role in the export-oriented Malaysian economy, generating $7.1 billion in 1990, or 8.9 percent of total export revenue.[3] Much previously forested land has been converted to agricultural uses, in particular, tree crop production. Tree crops, primarily palm oil, rubber, and cocoa, currently account for around 60 percent of Malaysian agricultural production,[4] as well as over one-third of world rubber exports and two-thirds of palm oil exports.[5]

Following independence, in 1957, when rubber accounted for nearly half of export revenues, an initial task of the Malaysian Government was to diversify its export base. This was done in successive stages through increases in exports of tin, petroleum products, palm oil and, more recently, manufactured products such as computer components (see table 1). Growth in manufacturing resulted in part from Government

[3]Sixth Malaysia Plan 1991-1995, p.22.
[4]Sixth Malaysia Plan 1991-1995, p.93.
[5]AGROSTAT.

Table 1—Malaysia: Sources of export revenue

Commodity	1960	1970	1980	1990
	Percent of total exports			
Rubber	48	33	16	4
Tin	17	19	9	1
Petroleum	3	4	24	13
Palm oil	2	5	9	6
Logs and timber	6	16	14	9
Other	24	23	28	67

Source: International Financial Statistics, International Monetary Fund.

efforts to vertically integrate natural resource-based industries and expand the role of noncommodity exports. The forest product industry was seen by the Government as an integral part of both diversification and integration efforts, contributing to the rapid growth in timber extraction (see fig. 1).

National and State Governments own most of Malaysia's forests and have directed the growth of the logging industry since independence. Private interests have also played an integral role in the timber industry by carrying out timber extraction and processing. National and State Governments grant logging concessions to the private sector, allowing the harvest of specified quantities of timber on particular sites and within particular timeframes, in exchange for fees and royalties. After harvesting, concessionaires process extracted logs, sell logs to sawmills or other wood processors or, until the late 1980's, export whole logs.

The products derived from Malaysian forests can be divided into three main categories: roundwood, sawnwood, and woodbased panels. Roundwood consists of wood in its natural state as felled or otherwise harvested, though it may also be impregnated (for example, telegraph poles) or roughly shaped. Roundwood production in Malaysia is made up principally of saw and veneer logs, which are logs to be sawn lengthwise for the manufacture of sawnwood and woodbased panels. Sawnwood consists of products such as planks, beams, joists, and laths, which may be planed, grooved, or jointed, but which typically exceed 5 millimeters in width. Woodbased panels include products such as plywood, particle board, and veneer. Malaysian timber is also increasingly used in domestic furniture manufacturing and in the production of moldings and other more highly processed wood products.

As late as 1987, approximately 50 percent of all timber production in Malaysia was exported as roundwood, and Malaysia still provides more than one-eighth of the world's roundwood trade.[6] Most of Malaysia's roundwood exports go to the Asian markets of Japan, South Korea, and Taiwan. Sawnwood is shipped primarily to The Netherlands, the United Kingdom, and Belgium, while more highly processed woodbased panels are exported, principally to the United States and Europe.[7]

To a large extent, the differentiation of Malaysian wood product exports, by degree of manufacturing and geographic location, reflects differentiated tariff structures around the world. Japan, for instance, places no tariffs on imports of unprocessed logs and relatively high tariffs on processed wood products. The European Community's tariff structure is less steeply graduated, with no tariffs on unprocessed log imports, 4-percent tariffs on semiprocessed products and 6-percent tariffs on highly processed wood products. The U.S. tariff structure is not graduated by degree of processing.

International and Domestic Concerns

As problems associated with deforestation have grown, the system of Government forest ownership and sale of harvest concessions in Malaysia has received increased criticism, especially from international sources.[8] Some critics hold that Malaysian forestland should belong to local populations rather than be under the control of the Government. The Penan people of Sarawak have received considerable international attention in this regard.[9] In addition, concessionary sales are not a matter of public record and are widely believed to be controlled mainly by individuals within or connected to the Government. Concessionaires are also not carefully monitored, partly because of insufficient resources, and have been accused of over-extraction and damage to standing forests.[10]

The criticisms of Malaysian forest policy are fueled by reports from external sources. One report, released in 1990 by the International Tropical

[6]AGROSTAT.

[7]The statistics reflect, to varying degrees, entrepôt status and not necessarily final lumber destinations.

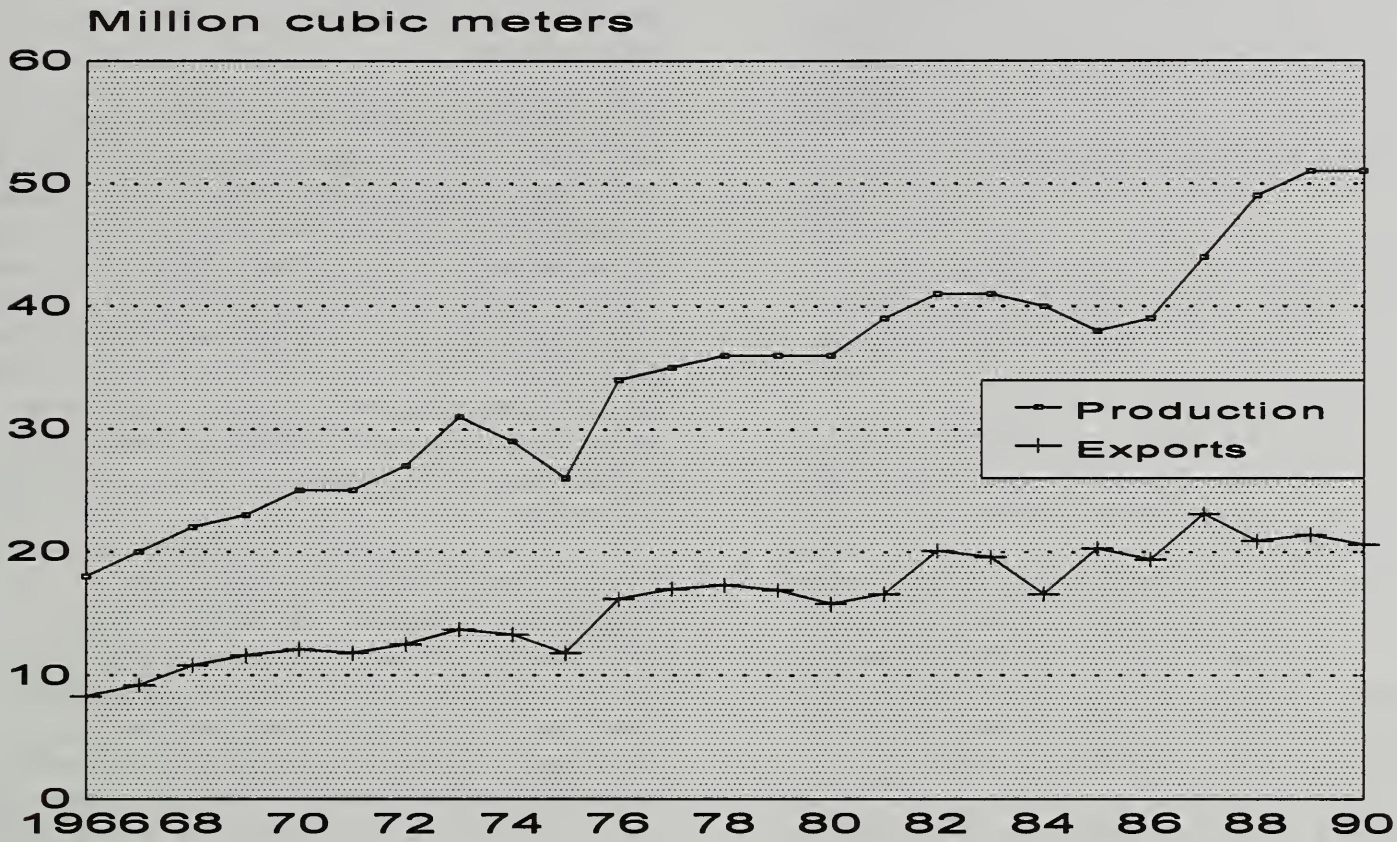
[8]See Reinhardt, pp. 1-4 and World Development Report 1992-93, pp. 123-24 for discussion and citations.

[9]Sierra and Taft.

[10]See the Economist, August 18, 1990, p. 23 and Reinhardt, pp. 11-12.

Figure 1

Roundwood production and exports, 1966-90



Source: Food and Agriculture Organization, United Nations.

Timber Organization (ITTO), predicted that Sabah will be logged out by 1995, and Sarawak will have no virgin forests by 2001.[11] Malaysia's prime minister has consistently responded unfavorably to outside intervention in Malaysian forest policy. His Government has stated a basic mistrust of developed country intentions towards the developing world. He feels the preoccupation with developing country forest policies, in particular, to be inconsistent with the known complexity of global environmental problems. The Government of Malaysia (GOM), citing estimates that the richest 20 percent of the world produces 80 percent of the world's ozone-depleting gases, has pointed out that many of the world's most serious environmental problems stem, in fact, from the industrialized world.

In addition, at least some Government leaders believe environmental groups attempting to interfere with Malaysian timber extraction are willing collaborators or unsuspecting dupes of timber companies in the developed world who wish to limit competition in timber trade. The GOM's position has been that Malaysia's forests belong to Malaysia, are not a world resource, and failure to use them hinders Malaysia's economic development. Even so, the GOM has recognized that past forest management practices have not been compatible with sustaining longrun harvests and need to be modified if Malaysia is to maintain its forest reserves.[12]

Malaysian Policy Change

Though the catalyst for change can be disputed, the GOM and State Governments have increasingly used policy measures to attempt to control the extent and direction of deforestation as concern over forest loss and associated environmental degradation has grown. Recent changes in Government policy have sought to reconcile both long- and short-term economic concerns. The

[11]As quoted in the Economist, Feb. 15, 1992, p. 37.

[12]Sixth Malaysia Plan 1991-1995, pp. 109-111 and The Second Outline Plan 1991-2000, pp. 135-137.

GOM has made clear that, from a national and long-term perspective, it is concerned with logging damage to the environment, for instance in terms of land degradation and soil erosion.[13] In addition, the Government, aware that past logging rates are unsustainable, believes that "It is crucial that the nation's forestry resources be strictly managed on a sustained yield basis in the Plan period and beyond...."[14] Consequently, one leg of the GOM's forest policy is to increase the quality and extent of forest management, reduce logging rates to sustainable levels, and protect the longer term viability of the timber and timber product sectors.

Still, the Government is also concerned with the current economic health of the country in general and the timber industry in particular. Recognizing the potential loss of jobs and income that a major slowdown in logging might cause, the Government has made efforts to increase domestic value-added processing of forest products. These efforts are reflected in increased production and employment in timber processing during the 1980's, including a 39-percent increase in sawnwood production and 51-percent growth in woodbased output.

A strategy of offsetting income and job losses from reduced logging and exports of unprocessed timber with increased employment and export earnings in value-added products is at least partially dependent on complementary trade policies in major importing countries. The graduated tariff regimes of the EC and, particularly, Japan, would tend to impede Malaysian exports of value-added products, while the ungraduated tariff structure in the U.S. market would tend to be more supportive of such exports.

Measures to Reduce Timber Extraction

As early as 1977, Peninsular Malaysia enacted a National Forest Policy under which approximately 40 percent of the total land area was classified as "permanent forest." The forest in this area is to be managed under sustained-yield principles with emphasis on compensatory plantings and silvicultural treatment. Other measures such as the Forest Conservation Policy, the establishment of national parks, planting programs emphasizing rapidly growing species, and the 1984 signing of the International Tropical Timber Agreement under the auspices of ITTO, an agreement aimed at sustained forest utilization and the conservation of tropical forests, have been implemented to control deforestation.

On a regional basis, Peninsular Malaysia has adopted regulations requiring at least 32 trees, 30 centimeters or more in diameter, to be left standing on each hectare of land after logging. According to one source, the World Bank believes this "is one of the best attempts in the world to make tropical forestry sustainable."[15] Authorities in Peninsular Malaysia also encourage the use of integrated log factories performing multiple wood processing tasks, the introduction of small-diameter log factories and chipboard plants, all of which reduce timber wastage.

To encourage domestic processing and employment generation, the GOM has given preferential treatment to the Malaysian timber processing industry, including granting pioneer status (a preferential business classification), investment tax credits, accelerated depreciation allowances, and reductions in royalty rates. Somewhat paradoxically, regulatory restrictions have also been used to control entry into wood-processing industries, ostensibly to attract potential investors and encourage investment from existing producers by decreasing the risk from competition and increasing profitability. It is not clear whether incentives to expand processing capacity have the immediate effect of slowing or accelerating deforestation. However, when combined with enforcement of logging rates, they create the conditions to maintain local employment and incomes as logging contracts.

Market intervention is also used to regulate unprocessed log exports. Peninsular Malaysia banned whole-log exports in early 1985, while the East Malaysian States of Sabah and Sarawak did the same in late 1989. The log export bans were designed primarily to divert wood processing activities from foreign to domestic markets. While domestic wood-processing activities have increased, export bans in the Bornean States have not been rigidly enforced, and as a result, total Malaysian roundwood exports declined only slightly even after the bans were imposed.

[13]To obtain an impression of official Malaysian sentiment on environmental control in general see: Department of Environment, Environmental Impact Assessment(EIA). Procedure and Requirements in Malaysia, Kuala Lumpur, March 1992; The Kuala Lumpur Accord on Environment and Development (1990); and The Langkawi Declaration on the Environment (1989).

[14]Sixth Malaysia Plan 1991-1995, National Printing Department, Kuala Lumpur, Malaysia. 1991. P. 110.

[15]The Economist, Feb. 15, 1992, p. 37.

Political Constraints

Despite Government efforts, significant political constraints exist which hinder the implementation of forest policy reform. A key constraint is that, for historic reasons, the national Government does not have full sovereignty over forest policy in all States. In West Malaysia, where the most far-reaching timber policies have been instituted, the Federal Government was given control of forests previously under control of the 11 West Malaysian States. However, the East Malaysian States of Sabah and Sarawak--whose level of economic development is much lower than Peninsular Malaysia--chose to retain control of their holdings. A primary reason for this decision is that taxes on timber extraction and exports are the main source of income for the State Governments. Even as late as 1991, timber export revenues constituted 70 percent of Sabah's State revenue.[16]

Bornean timber trade also appears to be more closely intertwined with the political system than is timber trade in Peninsular Malaysia, and individuals associated with Bornean Governments are reported to control the majority of timber concessions.[17] However, because of historic developments and the diffusion of power inherent in Malaysia's federated system, the national Government is unwilling to encroach on eastern State forest policy for fear of further dilution of political control. As a result, the GOM has, until recently, made only limited progress in controlling aggregate national timber extraction and log exports despite considerable success in some regions--primarily West Malaysia. (See table 2.)

Linkages Between Timber Policy and Trade

Despite conflicting views between the GOM and the developed world, conflicts of interest and difficulty in policy enforcement, policy changes such as those discussed have begun to have an impact on Malaysian timber trade, an impact which will likely increase in the future. It has been only since 1989 that policy changes have resulted in actual declines in timber extraction and unprocessed log exports. The inability of the national Government to have a greater impact on deforestation and log trade despite stated intentions and outright bans on unprocessed log exports can be attributed to at least two factors. First, the decline in deforestation rates and log exports from Peninsular Malaysia was largely offset by increases from Sarawak, over which the GOM had only limited control. Second, because of the remote locations of timber stands and lack of incentive for enforcement, widespread smuggling occurred.[18]

Due to these two factors, the Government has not been able to ensure that increased domestic roundwood utilization came at the expense of, rather than in addition to, additional exports. In fact, log production growth, averaging 0.8 percent annually from 1980-85, grew to 5.6 percent from 1986-90, suggesting perhaps an effort on the part of harvesters to step up production in order to supply both domestic and foreign demand before regulations and supplies became more restrictive.[19]

The outlook for the future control of timber extraction in Malaysia appears brighter. Many of the impediments to controlling logging rates have been at least partially solved. In particular, the national Government has recently offered to compensate State Governments for the loss of tax revenues from roundwood exports, and already national sawlog production has declined from peak 1989 levels.[20] Government forecasts of the projected slowdown in sawlog production and trade, though likely overstating the potential to control deforestation, are shown in figure 2.

The combination of changing domestic industry structure and slowing deforestation portends a significant change in Malaysia's role as a hardwood exporter. The growth in domestic forest product processing, combined with demands for construction materials to support rapid economic growth, will require larger timber supplies. While past expansion in domestic processing was met simply by increases in extraction, most future domestic use will come at the cost of roundwood exports--particularly in view of declining roundwood supplies. Already, Peninsular Malaysia, which currently does not export logs, requires log

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[16] Business Times, January 9, 1992.

[17] See the Economist, February 15, 1992, p. 37 and Taft, p. 10.

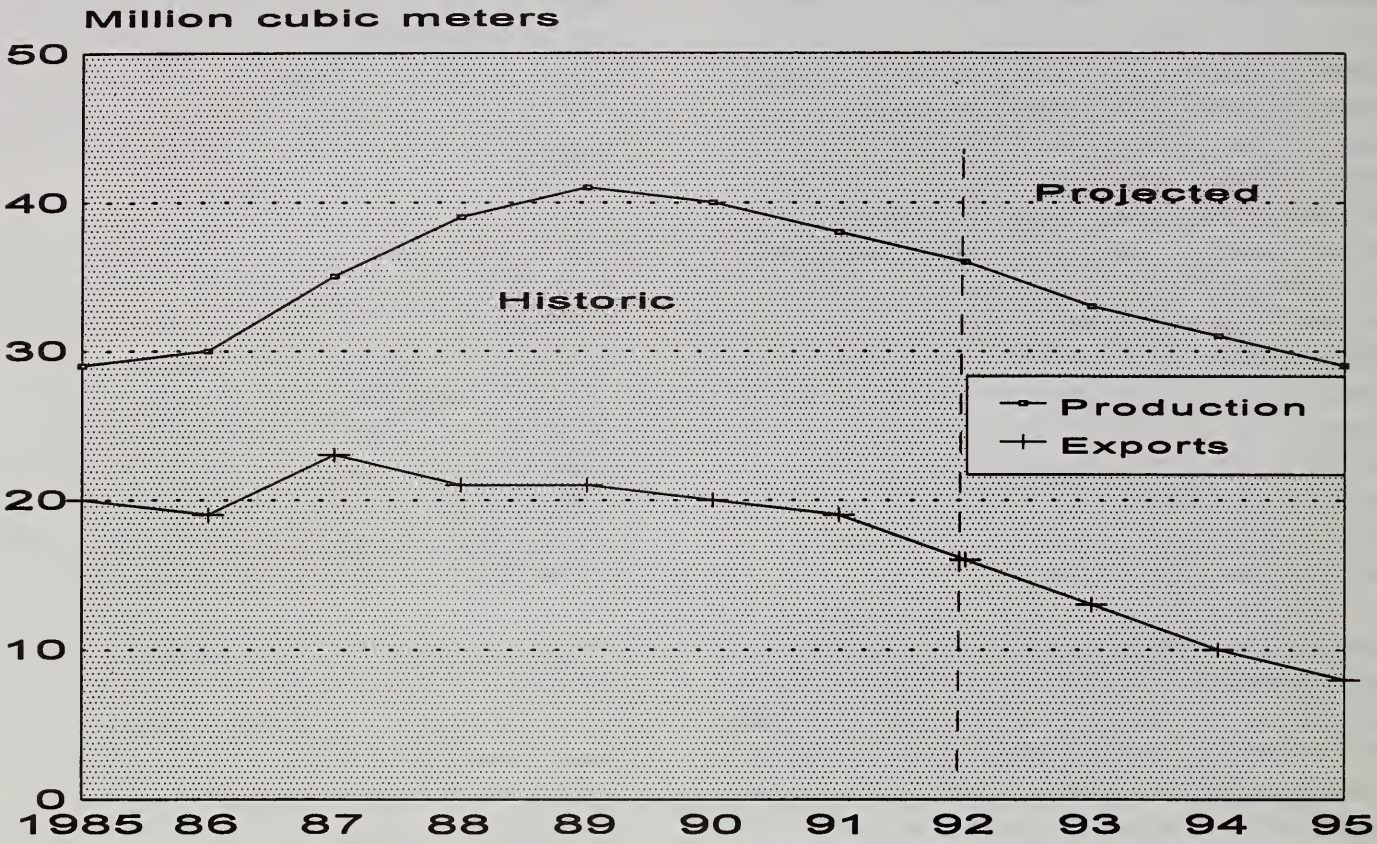
[18] The extent of illegal cutting and export of logs is difficult to determine, but is believed to be widespread (See Economist Intelligence Unit 1991-92, Malaysia, p. 22 and Reinhardt, pp. 11-12). As a result, trade and production statistics probably belie the true extent of deforestation in Malaysia.

[19] AGROSTAT.

[20] The principal component of Malaysian roundwood production is sawlogs. Data are not yet available for roundwood production after 1990.

Figure 2

Historic and projected sawlog production and trade



Source: Government of Malaysia.

Table 2—Malaysia: Production and exports of wood products, by region

Item	Units	Logs	Sawnwood	Plywood and veneer
West Malaysia				
1980 production	*1,000 CUM*	10,453	5,340	772
1990 production	*1,000 CUM*	10,620	6,573	956
Average annual growth	*Percent*	.2	2.1	2.2
Exports' share of production (1990)	*Percent*	0	45	74
Sarawak				
1980 production	*1,000 CUM*	8,399	357	23
1990 production	*1,000 CUM*	18,838	585	196
Average annual growth	*Percent*	8.4	5.1	23.9
Exports' share of production (1990)	*Percent*	84	61	94
Sabah				
1980 production	*1,000 CUM*	9,063	542	104
1990 production	*1,000 CUM*	8,445	1,910	456
Average annual growth	*Percent*	-.7	13.4	15.9
Exports' share of production (1990)	*Percent*	54	103	94
Total				
1980 production	*1,000 CUM*	27,915	6,239	899
1990 production	*1,000 CUM*	37,903	9,068	1,608
Average annual growth	*Percent*	3.1	3.8	6.0
Exports' share of production (1990)	*Percent*	54	58	82

Source: "Statistics on Commodities," Malaysia Ministry of Primary Industries.

shipments from East Malaysia to meet construction demand and demand from existing downstream processors. In the future, we can expect to see a declining Malaysian role in world sawlog and sawntimber markets as domestic users, already provided with preferential investment and trade treatment, are granted available supplies.

While many may applaud the probable decline in Malaysian deforestation, it is not clear that a sustained reduction in Malaysian deforestation will not be offset by larger, perhaps unsustainable, harvests in other countries, for example, Myanmar and the nations of Indochina (see fig. 3).[21] This point should be of particular importance to international environmental groups who have sought unilateral action on the part of Malaysia. It may also indicate that such actions as the call for a ban on imports of Malaysian timber may, in fact, punish a country attempting, however imperfectly, to solve its environmental problems while more apathetic countries are left untouched.

Tree Crops, Forest Management, and Trade

The direct impact of changes in forest policy has been, and will likely continue to be, declines in timber extraction rates and roundwood exports coupled with increases in the share of timber exported in value added form. However, other secondary affects will also influence Malaysia's role in world agricultural trade. Forest policy can potentially play an important role in Malaysian production and exports of tree crops, including rubber, cocoa, coconut, and, in particular, palm oil.

Malaysia has been a major rubber producer since the early twentieth century under British rule, and until recently, rubber was Malaysia's primary source of foreign exchange. However, after independence, the Government attempted to diversify the agricultural economy, in part by deemphasizing rubber in favor of palm oil. Rubber remains an important commodity in the economy. Malaysia is still the world's second largest exporter, as well as a major exporter of processed rubber products. However, palm oil now surpasses rubber in its contribution to export earnings and accounts for nearly one-third of world edible oil trade.

[21]Of course, the increase in logging in both Myanmar and Indochina is at least partially attributable to the political and economic environments currently existing in those areas.

Increased palm oil production has come from both area expansion and yield growth made possible by technological advances. However, yield growth has slowed from 4.8 percent per year from 1970-80 to only 1.0 percent from 1980-90, indicating the growing importance of area expansion in increasing output as existing technologies reach their limits. Expansion of palm oil area will be increasingly correlated with new land availability, which historically has come from previously forested areas.

In fact, simple regression analysis of the period 1975 through 1990 suggests that each hectare of deforested land is correlated with approximately a 0.5-hectare increase in the expansion of palm oil area.[22] As forest use policy continues to become more stringent, one would expect to see continued declines in the amount of new land made available for production of oil palm and other crops. As production growth slows, so will palm oil exports, a fact compounded as domestic palm oil use expands with economic growth. However, 5 to 10-year lags will exist between changes in forest management and changes in palm oil trade, due to the long time requirement between initial land development and crop production.

Conclusions

Malaysia has used its forest resources as an integral part of its postindependence development policy. Despite international controversy over the environmental damage caused by its timber extraction policy and enforcement, the GOM has stood by its claim that Malaysian resources are a national possession and should be managed as such. Still, as stated in its recent development plans, the GOM has recognized that, even from a national perspective, its forest management policies have caused considerable environmental damage and extraction rates have been above sustainable levels.[23]

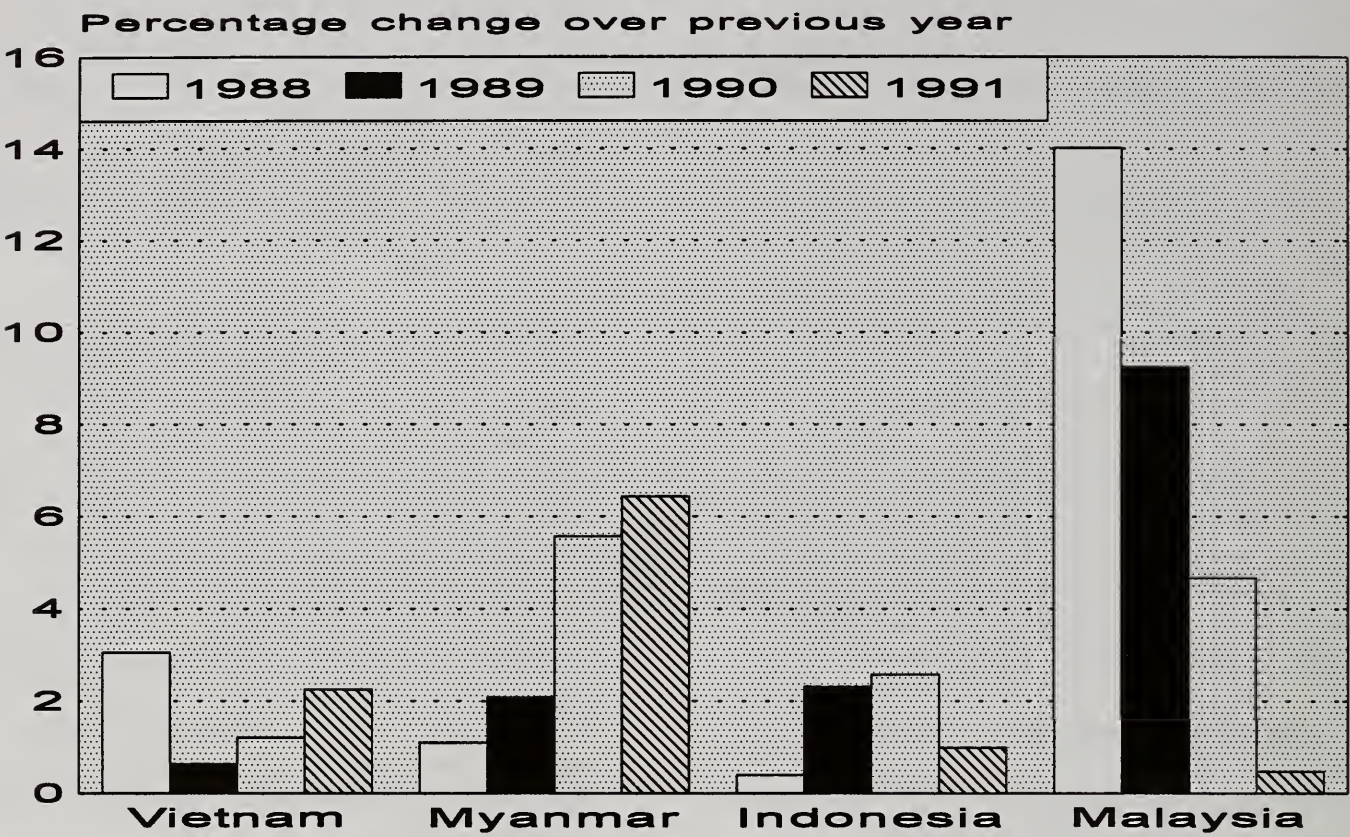
The GOM has taken significant steps in recent years, driven by both economic concerns and environmental realities, to modify its forest sector

[22]The simple equation estimated was Palm Oil Area = 10,909 - .47 * Forested Area, $R^2 = 0.97$. This equation should be interpreted merely as a general indication of the correlation between palm oil area and deforestation. Accurate assessment of Malaysian deforestation, as with most other countries, is problematic for a number of reasons, including difficulty in measurement and making qualitative comparisons. The data used here were based on FAO Yearbook, Forest Products.

[23]Sixth Malaysia Plan pp. 109-111 and The Second Outline Plan p. 137.

Figure 3

Growth in sawlog production for selected countries



Source: Food and Agriculture Organization Yearbook.

policies. While it is not clear that all policy measures instituted will contribute to declines in deforestation rates, it does appear that the net impact has been and will continue to be declines in timber extraction. As a result, Malaysia could lose its position as the world's largest exporter of hardwood logs. In addition, Malaysia's more restrictive forest management practices will increasingly constrain extensive expansion in tree crop area, contributing to a slowing of growth in Malaysian rubber and, especially, palm oil exports.

In applying the Malaysian experience to analysis of tropical timber policy and trade linkages in other countries, three main points should be noted. First, even when the need to change environmental policy was recognized, considerable obstacles to implementation existed. These included ill-defined property rights, enforcement problems and counterproductive incentive systems, which greatly increased the lag between the implementation of policy and changes in trade patterns. Second, there is some evidence that a unilateral reduction of deforestation rates by Malaysia may be met by increased extraction--perhaps at unsustainable rates--in neighboring countries. While this does not imply that unilateral action is inappropriate to solve national forestry problems, it does bring into question the efficacy of such approaches in addressing aggregate global forest resource issues. Finally, and perhaps most importantly, it is clear that timber and other environmental policies can have effects, both positive and negative, beyond their direct sphere of influence, which should be considered in both their evaluation and design.

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Chapter 14

Global Climate Change: Analyzing Environmental Issues and Agricultural Trade within a Global Context

Roy Darwin, Jan Lewandrowski, Brad McDonald, and Marinos Tsigas

In many areas, relatively small changes in climate could dramatically alter the mix of crops and livestock that are economical to produce. Hence, there is considerable interest in how climate change might affect world food systems. This paper presents a new framework whereby: (1) climate change affects the production possibilities associated with land resources throughout the world; and (2) the resultant shifts in regional production possibilities affect current patterns of world agricultural output and trade. The framework combines the features of a geographic information system (GIS) with those of an applied general equilibrium (AGE) economic model.

We analyze the impacts on world commodity production of a climate change scenario generated by the General Circulation Model of the Goddard Institute for Space Studies. Based on our results obtained from the geographic information system (GIS), we find that, under this scenario, production possibilities for crops and livestock increase for the world as a whole. Not all commodities benefit, however. Production possibilities for tropical nongrain crops decline. Our results also indicate regional shifts in comparative advantage for some important agricultural commodities. In the United States, for example, comparative advantage deteriorates for maize and feed-intensive livestock (dairy and pork), and improves for wheat and short-season grains.

From a broader environmental perspective, our results indicate that arctic and tropical ecosystems would be reduced in size under this climate change scenario. In the tropics, this reduction implies that climate change could significantly intensify the pressures now facing natural environments from increasing human populations and expanding agricultural production.

Introduction

In much of the world, crop and livestock production occurs near the margin of economic viability. This margin is often related to local climate conditions. Hence, relatively small changes in mean global temperature and/or precipitation levels could dramatically alter regional patterns of world food production. In developing countries, for example, Rosenzweig and Parry (1994) estimate that, above a reference case of 641 million, climate change could put as many as 350 million more people at risk from hunger by 2060.

In analyzing how climate change might affect agricultural systems, it is important to recognize that: (1) the environmental and economic impacts of climate change will be global; (2) agriculture will be one of many affected economic sectors; and (3) in any region, agriculture's response to climate change may have economic implications for agricultural sectors in other regions. Climate change is also likely to stress some natural ecosystems and agriculture, in responding to new environmental conditions, may significantly compound these stresses. For example, Adams and coauthors (1990), find that U.S. producers could adapt to climate change by increasing irrigation but at a cost of less water for natural environments.

Several economic models have been developed to analyze the impacts of climate change on regional and world agricultural markets (see Appendix 1). As yet, however, no framework exists that adequately accounts for interactions among economic sectors, among geographic regions, and between economic sectors and the environment. To capture these interactions, the Economic Research Service is developing the Future Agricultural Resources Model (FARM).

FARM is a multisector, multiregion framework designed to analyze the effects of exogenously specified climate change scenarios on agricultural production, trade, prices, and consumption. FARM rests on four concepts. First, land is treated as a heterogeneous resource. Specifically, regional land endowments are disaggregated into land classes

reflecting different agricultural production possibilities. Second, each type of land is modeled as a production input in all economic sectors. Third, climate change alters the distribution of acreage among the land classes. Within a region, the effect is to shift the production possibilities associated with the aggregate land endowment. Finally, economic impacts resulting from changes in regional land class endowments are evaluated in a global general equilibrium context.

FARM consists of a geographic information system (GIS) and an applied general equilibrium (AGE) model. The GIS helps determine: (1) how regional commodity production is distributed across land classes under current climate conditions, and (2) how hypothetical climate change scenarios alter regional distributions of acreage among the land classes. The AGE model takes the climate-induced changes in regional land class endowments and evaluates the effects on production, trade, prices, and consumption in the global economy.[1] This paper focuses on the GIS component of FARM. The GIS allows climate change scenarios to affect the production possibilities of land resources. Regional land areas are disaggregated into six land classes differentiated by length of growing season; growing seasons are functions of monthly temperature and precipitation levels. For a given parcel of land, imposing new temperature and/or precipitation levels (that is, a climate change scenario) may alter the land class to which the parcel is assigned. Through such reassignments, climate change alters regional endowments of the six land classes.

The GIS also helps associate a commodity output mix with each region-land class combination. Hence, changes in a region's land class endowments imply potential reallocations of inputs among commodities and potential changes in the agricultural output mix of the region. The logic here is that commodity production is finely tuned to climate conditions and so, one way to assess how a set of producers might respond to new climate conditions is to look at commodity production in areas where those conditions already exist. A number of studies use this "analogous regions" approach to look at potential impacts of climate change on crop production patterns (Blasing and Solomon, 1982; Rosenzwieg, 1993; Parry, 1990). To date, such studies have been region-specific and typically lack formal economic structure.

By contrast, economic studies tend to simulate the impacts of climate change on crop yields, and then incorporate these yield effects into economic models that capture supply and demand responses to changing prices (see Appendix 1). In most cases, land is not explicitly modeled as an input. Hence, there is an implicit assumption that the quantity of land in commodity production adjusts to produce the output levels obtained in the economic models.

By linking land resources to climatic conditions and regional commodity production, our GIS methodology extends the analogous regions approach to a global scale. With respect to modeling economic impacts of climate-change scenarios on world agriculture, this means: (1) allowing more flexibility with respect to crop choice in any given area; and (2) accounting for climate-induced shifts in the production possibilities of regional land resources.

The paper is organized as follows: Section 1 describes the method for defining land resources based on differences in agricultural productivity. Section two shows how these differences are reflected in current economic activities. A hypothetical climate change scenario is presented and analyzed in section three. Section four contains a summary and conclusions.

Land Resources

FARM's GIS describes global land resources in a way that allows events like climate change to have different impacts on agricultural production possibilities in separate regions of the world. The GIS can be thought of as a grid covering a map of the world. The cells of the grid contain information from several global data bases about the associated area's climate, natural resources, current land use, national borders, and so forth. In general, the spatial resolution of the data bases is 0.5° latitude and longitude (360 rows by 720 columns). Pictures of current and potential land use patterns under present and hypothetical climate conditions are obtained by sorting the information contained in the data bases by GIS grid.

[1]Economists use multiregion AGE models to simulate the world economy. Using various elasticities and macro-level data on trade, consumption, production, and input-output relationships, these models compute changes in prices, production, consumption and trade that result from exogenous disturbances to regional and world markets.

Land varies immensely with respect to agricultural productivity. To capture this heterogeneity, the world's land area is distributed among six classes differentiated by length of growing season. Growing season lengths are computed from monthly temperature and precipitation data using Newhall's (1980) method.[2] Newhall's method has been used by Eswaran and Van den Berg (1992) to evaluate climate change impacts on the Indian subcontinent.

The six land classes, defined in table 1, correspond (approximately) to important differences in agricultural production possibilities. Land Classes (LCs) 1 and 2 have growing seasons of 100 days or less. LC 1 is mostly polar and alpine areas, so the short growing seasons are due to cold temperatures. Production on LC 1 is primarily sparse forage, but some crops can be produced where growing seasons approach 100 days. LC 2 is mostly desert and marginal grasslands, so growing seasons are limited by low precipitation levels. Large areas of LC 2, however, are irrigated, which extends both growing seasons and production possibilities. Without irrigation, production is limited to areas where growing seasons approach 100 days. On LC 3, growing seasons range from 101 to 165 days. This is suitable for wheat, other short-season grains, and forage. Growing seasons on LC 4 are from 166 to 250 days, long enough for maize. Globally, LC 4 accounts for more maize and wheat output than any other land class. LC 5 has growing seasons of 251 to 300 days. Major crops include cotton and rice. On LC 6, crops can be grown year round. In addition to rice, major crops include rubber, sugarcane, and (in the tropics) maize. The six land classes also correspond to differences in multicropping potential. Production on LC 1, 2 (without irrigation), and 3 is limited to 1 crop per year. Some double-cropping occurs on LC 4. Two or more crops per year are common on LC 5 and 6.

Table 2 and figure 1 show the global distribution of land among the land classes. LC 1 and 2 contain almost half of the world's 13.1 billion-hectare land area; LC 6 accounts for 20 percent and LC 3, 4, and 5, together, account for about 30 percent.[3] Table 2 also shows land class distributions for the United States, Canada, Europe (including Greenland), the former USSR (including Mongolia), Japan, and Australasia (Australia and New Zealand), Other Asia, Latin America, and Africa. The first five regions are in the group "Temperate;" the last three are in "Tropical." As expected, endowments vary substantially across regions. LC 1 and 3, for example, are more common in temperate regions; LC 5 and 6 are more prevalent in the tropics. In the United States, 46 percent of the land is LC 1 or 2, 12 percent is LC 6, and 42 percent is LC 3, 4, or 5.

Current Land Use

The GIS is used to allocate current crop, livestock, and forestry production in each region across the land classes. The purpose is to associate a commodity output mix with each region-land class combination. For some commodities (for example, wheat, maize, rice, and livestock) and some countries (for example, the United States and India), detailed location of production data are available. For most commodities and most countries, however, this is not the case. What are generally available are Food and Agriculture Organization production data by country and commodity (FAO, 1990). Here, we describe a method that uses the FAO data (aggregated to the regions described above), the GIS, and several other global data bases to distribute regional crop, livestock, and forestry production across the land classes.[4] The methodology has the advantages of being global in coverage and consistent for all regions.

To start, all acreage in each region-land class combination is allocated among four land-use types--arable land (including land in permanent crops), permanent pasture, forest, and other. These allocations are primarily based on Olson's (1989-91) distribution of land uses and covers, modified so that each region's totals for agricultural land (arable land plus land in permanent crops and pasture), forest, and other land match those in FAO (1990).[5]

[2]The methodology is a simplification in that it ignores several variables that affect growing season length--such as soil depth and texture. Length of growing season data were computed by the World Soil Resources Office of USDA's Soil Conservation Service from Leemans and Cramer's (1991) temperature and precipitation data.

[3]Antarctica is not included in this analysis.

[4]A complete description of the methodology is available in The Future Agricultural Resources Model (FARM): Documentation (Roy Darwin, Marinos Tsigas, and Jan Lewandrowski). Unpublished manuscript available from the authors.

[5]Olson (1989-91) contains information on primary land use and cover worldwide at a resolution of 0.5°. We aggregate 18 of Olson's land use and cover categories into four land uses. For example, our distribution of forestland is derived from Olson's distributions of conifer forest, broadleaf forest, mixed forest, tropical forest, forest-field mixtures, northern taiga and alpine meadows, conifer rainforest, and mangrove forest categories (see footnote 4).

Table 3 presents quantities of arable land, permanent pasture, forest, and other land by region and land class. About 11 percent of the world's land area is currently arable, 26 percent is pasture, 31 percent is forest, and 32 percent is in other uses. Table 3 also shows how land use varies across the land classes. For example, LC 4 accounts for 10 percent of all land but 25 percent of all arable land. Relatively large shares of LC 3 and 5 are also arable. LC 2 includes 32 percent of all land, 20 percent of all arable land and 45 percent of all pasture. LC 6 contains 20 percent of all land but 36 percent of all forests. Together, LC 1, 3, and 6 account for 75 percent of all forests. Only about 10 percent of LC 5 and 6 is not used for arable land, pasture, or forest. By contrast, 50 percent of LC 1 falls into the "other" land use category. In the United States, arable land accounts for 20 percent of LC 3, 47 percent of LC 4, 27 percent of LC 5, and 15 percent of LC 6.

The second step in describing current land use patterns is to allocate commodity production in each region to the land classes. For crops, the allocation is based on regional production data from FAO (1990). Regional crop production is regressed on regional land class endowments with the endowments weighted to reflect each land class's share of arable land. Most crops are allocated based on the regression results (see footnote 4). Table 4 shows production quantities, by land class and region, for five crop aggregates: wheat and other cool-season grains (barley, rye, and oats), paddy rice, maize and other temperate grains (sorghum and millet), tropical nongrains (sugarcane, coffee, cocoa beans, natural rubber, and tea), and ubiquitous nongrains (roots and tubers, pulses, tree nuts, oil crops, vegetables, fruits, sugar beets, hops, tobacco, and fiber crops).

For livestock, regional production data from FAO (1990) are distributed among the land classes based on animal densities in Lerner and coauthors (1989). For various livestock, Lerner and coauthors give head per km^2 at a grid resolution of 1.0°. Hence, allocating livestock by region and land class is straightforward in the GIS. Table 5 gives livestock numbers by animal, region, and land class.

Regional forestry outputs are obtained from FAO (1990) production data for coniferous and nonconiferous industrial roundwood and fuelwood. In each region, forest products are allocated to the land classes based, in part, on distributions of coniferous, broadleaf, and mixed forests derived from Olson (1989-91). Mixed forests are assumed to be half coniferous and half nonconiferous. To capture productivity differences among land classes, each land class's area of coniferous or nonconiferous forest is multiplied by the maximum number of days in the growing season to compute its number of hectare-days. The allocation of forest production in each region is based on each land class's share of hectare-days (see footnote 4). Tables 6 and 7 detail forest acreage and production by region and land class.

Tables 4-7 show how the procedures described above distribute commodity production across land class endowments. In table 4, for example, 49 percent of world wheat and cool-season grains production occurs on LC 2 and 3. Adding LC 4 accounts for 86 percent of world output for these crops. Regionally, Europe, the former USSR, and Other Asia are the largest producers of wheat (and other cool-season grains). Not surprisingly, the former USSR has 32 percent of the world's LC 3 land, while Other Asia has 15 percent of the global endowments of both LC 3 and 4. Europe, on the other hand, has 13.6 percent of all LC 4 land and only 5 percent of all LC 3 land. LC 4, however, is intensely used for wheat production. Forty-nine percent of Europe's LC 4 land is arable, and this land accounts for 67 percent of the region's wheat output.

LC 4 accounts for 42 percent of world maize, millet, and sorghum production; adding LC 6 accounts for 65 percent. The United States and Other Asia are the largest producers of these crops. Each region has about 15 percent of the global LC 4 endowment; Other Asia also has 23 percent of all LC 6 land. In the United States, 47 percent of LC 4 is arable and this land accounts for 68 percent of the region's maize, millet, and sorghum output.

Sixty-three percent of all rice is grown on LC 5 and 6; regionally, Other Asia accounts for 90 percent of world output. Nearly 80 percent of all tropical nongrains are produced on LC 6. Ubiquitous nongrain crops are concentrated in LC 4, 5 and 6; collectively, these land classes account for 72 percent of world output. LC 1 is the least important land class for crop production; it accounts for 2 percent of all wheat and cool-season grains and trace amounts of rice and ubiquitous nongrains.

Figure 1
Land classes under current climate

Land Class
(length of growing season)

- LC 1 (0-100 Days and Cold)
- LC 2 (0-100 Days and Dry)
- LC 3 (101-165 Days)
- LC 4 (166-250 Days)
- LC 5 (251-300 Days)
- LC 6 (301-365 Days)

DATA SOURCES:
Growing Season: World Soil Resources Office, Soil Conservation Service, USDA
Land Classes: Darwin, Lewandrowski, McDonald and Tsigas, Economic Research Service, USDA
GIS Software: ARC/INFO (Environmental Systems Research Institute)

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Figure 2

Land classes under GISS 2 x C02 scenario

DATA SOURCES:
Growing Season: World Soil Resources Office, Soil Conservation Service, USDA
Land Classes: Darwin, Lewandrowski, McDonald and Tsigas, Economic Research Service, USDA
GIS Software: ARC/INFO (Environmental Systems Research Institute)

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Table 5 shows livestock distributions by animal, region, and land class. LC 2, 4, and 6 are the main land classes for livestock production. Because LC 2 is typically hot and dry, grazing is often its most economical use. LC 2 accounts for 22 percent of both dairy and nondairy cattle, 38 percent of all sheep and goats, and 29 percent of the group "Other." Livestock production on LC 4 is associated with feed-grain production. LC 4 accounts for 31 percent of all dairy cows and 34 percent of all pigs. For nondairy cattle, LC 6 is the most important land class. LC 1 is marginal for livestock production.

Tables 6 and 7 present two pictures of global forestry. Table 6 shows forest endowments by region, type, and land class. LC 1 and 3 account for 90 percent of all coniferous forests, while 75 percent of all broadleaf forests occurs on LC 5 and 6. Mixed forests are less concentrated; LC 2 has the least (7 percent) and LC 3 has the most (31 percent). Table 7 shows that 54 percent of all softwood harvests come from LC 1 and 3. For hardwood harvests, 75 percent come from LC 5 and 6. Softwood harvests in the United States are unusual in that almost 40 percent come from LC 6 (that is, the Southeast).

Climate Change Analysis

Using the geographic information system (GIS), we impose on the world a climate change scenario generated by the General Circulation Model (GCM) of the Goddard Institute for Space Studies (see Box 1). Specifically, we add to the Leemans and Cramer temperature data, the differences in temperatures obtained in GCM runs with current ($1xCO_2$) and double ($2xCO_2$) atmospheric CO_2 levels. The Leemans and Cramer precipitation data are multiplied by the ratio of GCM-generated precipitation in the $2xCO_2$ run to precipitation in the $1xCO_2$ run. Given the adjusted temperature and precipitation levels, new lengths of growing season data are computed, and all land is reallocated to the six land classes.

The land classes represent heterogenous inputs in commodity production. Any reallocation of land among a region's land classes then, represents: (1) a change in the mix of factors available for commodity production; and (2) a shift in the production possibilities curve (PPC) associated with the region's total land endowment. A PPC shows only what an economy can produce, not what it actually produces. Hence, results from our GIS methodology concerning potential impacts of climate change on agriculture reflect only changes in the suitability of regional/world land resources to the production of different commodities. Since our analysis does not include a formal economic model, we cannot say which, if any, production activities would change as suggested by the GIS results. Still, it makes sense that, where climate change significantly alters growing conditions, farmers will respond, at least on average, by shifting to commodities better suited to the new conditions.

Table 8 and figure 2 show global and regional land class endowments for $2xCO_2$ temperature and precipitation conditions. Comparing the land distributions in table 8 with those in table 2 (current climate conditions), suggests how this form of climate change might affect world land resources.

For the world as a whole, the greatest shift of land is out of LC 1. LC 1 loses 903 million hectares, or 40 percent of its current area. The second largest shift is into LC 4, which increases by 682 million hectares, or 51 percent of its current area. LC 3 gains 485 million hectares, an increase of 29 percent. Impacts are more modest for LC 2, 5, and 6. LC 6 decreases 10 percent; LC 2 and 5 are essentially unchanged.

We now develop hypotheses concerning some economic implications of the climate-induced shifts in land class endowments discussed above. We also draw on results from a stylized two-region AGE model with heterogeneous land resources (see Appendix 2). Because of the simplicity of the AGE model, reference to current commodity production patterns, omission of potential farm-level adaptations, and consideration of only one climate change scenario, we emphasize that we are not predicting the future. Our purpose is to show how the framework presented here facilitates analysis of issues dealing with agriculture, the environment, and trade in a global context.

With respect to world agriculture, there is a net increase of 8.4 percent in the land classes suited to crop and livestock production (LC 2 through 6). Increases in LC 3 through 5 indicate that the global potential for wheat, maize, and ubiquitous nongrains is likely to improve. The 10 percent decrease in LC 6, on the other hand, implies fewer production possibilities for tropical nongrains. Impacts on rice production are uncertain because the negative effects of less LC 6 land could be offset with additional irrigation. For rice

production, the key question is: How will climate change affect the availability of irrigation water? On balance, results support the hypothesis that climate change will increase the agricultural potential of the global land endowment.

The GIS and simple AGE model results, however, make it clear that shifts in global patterns of comparative advantage should be expected for some important agricultural commodities. The decreased production potential for tropical nongrain crops has been mentioned. In the United States, the 15-percent reduction in LC 4 land (30 million hectares) suggests some erosion of the region's position as the largest exporter of maize. On the other hand, the United States gets a 46-percent increase in LC 3 (53 million hectares). This could enhance its position as a major wheat exporter. For livestock, the loss of LC 4 in the United States suggests less production potential for feed-intensive dairy and pork. For grass-fed livestock, the implications are less clear. The United States loses 30 million hectares of LC 2. This land class accounts for, respectively, 25.6 and 57 percent of its nondairy cattle and sheep production. Gains in LC 3, 5, and 6 could, potentially, offset lost livestock production from LC 2. In the United States, however, LC 3, 5, and 6 are less important for livestock so the increased areas of these land classes may well go into production of other commodities.

In forestry, the 10 percent global reduction in LC 6 suggests less potential production of hardwood products. For softwood products, the implications are less certain. In temperate regions, potential output losses from LC 1 are offset by potential increases on other land classes, especially LC 3. In tropical regions, the potential for both softwood and hardwood products decreases.

Again, regional differences can be expected. In the United States, for example, production possibilities for softwood expand as increases in LC 3 and 6 offset losses in LC 1. Impacts on hardwood production are less certain. Increased production on LC 5 and 6 could offset lost production on LC 4. The increases in LC 5 and 6 land, however, could also be used for agriculture.

The impacts on agriculture and forestry may, as demonstrated by the simple AGE model, spillover into manufacturing and service sectors. Under the climate change scenario considered, there is a net decrease in LC 5 and 6 of 206 million hectares and a net increase in LC 2, 3, and 4 of 1,108 million hectares (table 8). In the aggregate, then, production possibilities for tropical commodities fall and production possibilities for temperate commodities increase. Such shifts would likely lead to changes in the relative prices of temperate and tropical commodities. If this happens, the results of Scenario 2 in Appendix 2 suggest economic effects outside of commodity sectors.

To see this, associate temperate regions with Home in Box 2 and the tropics with ROW. Also, associate LC 2, 3, and 4 with Land 1 and LC 5 and 6 with Land 2. In Scenario 2, both regions get an increase in Land 1. For Home (ROW) this is an increase (decrease) in the land type it is most endowed with. By analogy, temperate regions get an increase of 573 million hectares of LC 2, 3, and 4; the tropics get a decrease of 425 million hectares of LC 5 and 6. Market effects of Scenario 2 (see table B.1), include decreases in the price of grains (the commodity best suited to Land 1) relative to "other crops," and the noncommodity outputs of both regions. Because ROW's noncommodity good has a larger price increase than that of Home, Scenario 2 favors noncommodity production in the Home region. For the GIS results, the analogy with Scenario 2 suggests that climate change would favor noncommodity sectors in temperate regions relative to the tropics. The example, however, is only illustrative; the key point is that shifts in comparative advantage for noncommodity production are likely between temperate and tropical regions if climate change takes the form considered here.

Finally, climate change may adversely affect some natural ecosystems. Our GIS results show losses in LC 1 and 6, which implies that arctic and tropical ecosystems would be directly stressed. For tropical ecosystems, the direct impacts of climate change are likely to be compounded by agricultural factors. LC 6 is an important source of crops (for example, coffee, cacao beans, and sugarcane), some of which, may be less well suited to growing conditions on other land classes. Given increasing demands for agricultural land and shrinking endowments of LC 6, competition between tropical ecosystems (particularly tropical forests) and alternative land uses could significantly intensify. For arctic ecosystems, the impacts of climate change are not likely to be compounded by economic factors. LC 1 provides very little agricultural product and LC 3 can substitute for LC 1 as a source of softwood products.

Conclusion

A new framework for analyzing effects of global climate change scenarios on regional and world commodity markets is outlined in this paper, using GIS to: (1) link current patterns of commodity production to a set of heterogeneous land classes in each of eight global regions; and (2) simulate the impacts of climate change on regional land class endowments. As climate change alters the characteristics of each region's land resources, an applied general equilibrium model evaluates the economic impacts.

Implications of one popular climate change scenario were examined within the framework. Using the GIS results and a simple AGE model, a number of hypotheses were developed concerning the economic implications of this scenario. First, the scenario appears to increase the crop and livestock production possibilities associated with world's total land area. If true, impacts of climate change on world commodity prices should be small.

Second, regional commodity sectors could be significantly affected by climate-change driven shifts in global patterns of comparative advantage for economically important crops and livestock. For the United States, likely shifts include less potential for maize and grain-fed livestock and expanded production possibilties for wheat and short-season grains.

Third, shifting patterns of comparative advantage in commodity production could have spillover effects in noncommodity sectors. The land class changes considered here suggest that climate change would alter the relative prices of commodities from temperate and tropical regions. Viewed in the context of the simple AGE model, this observation raises the possibility of spillover impacts affecting the relative prices of services and manufactured goods from these regions.

Finally, through changing environmental conditions and human responses to those changing conditions, climate change is likely to stress some natural ecosystems. Our GIS results suggest that arctic and tropical ecosystems are most threatened.

The GIS-generated impacts on regional land class endowments must now be analyzed in FARM's AGE model to see if the implications developed in this paper concerning climate change and agriculture hold up in a formal, multisector, multiregion economic model.

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Appendix 1: Modeling Agriculture under Global Climate Change: A Review[6]

Economists have made a number of efforts to model the potential impacts of climate change on agriculture. These efforts include farm-level studies (Kaiser and coauthors, 1991), sector-level studies for specific regions (Adams and coauthors, 1990; Easterling and coauthors, 1992; and Mooney and Arthur, 1990), and studies of global commodity markets (Kane and coauthors, 1991; Reilly and Hohmann, 1993; and Rosenzweig and Parry, 1994). Regardless of focus, researchers have followed a similar road map. First, climate change scenarios are specified. Next, estimates are made about each scenario's impacts on crop yields. Finally, crop-yield effects are incorporated into an economic model to estimate each scenario's impacts on various agents, sectors, and/or geographic regions.

The most common sources of climate change scenarios are General Circulation Models (GCMs). GCMs are mathematical representations of climatic processes that can simulate global weather and climatic conditions over time for given values of atmospheric CO_2.[7] Typically, GCM results are presented as differences in mean monthly temperature and precipitation between model runs with one and two times current levels of atmospheric CO_2.

Most researchers simply adjust current temperature and precipitation levels by the differences suggested in GCM runs (Adams and coauthors, 1990; Arthur and Abizadeh, 1988; Rosenzweig and Parry; Mooney and Arthur). Kaiser and coauthors use GCM results to set parameters for a stochastic weather generator. The weather generator then produces daily weather data for periods of 100 years. To model climate change as a gradual and dynamic process, scenarios are imposed in increments by resetting the parameters for the weather generator every decade. Easterling and coauthors use analog climate. For the Missouri, Iowa, Nebraska, and Kansas (MINK) region, they assume climate change can be represented by the weather record from the 1930's (a historically hot and dry period for the MINK area).

Given a climate change scenario, most researchers employ crop-growth models to estimate the climate-induced effects on crop yields (Kaiser and coauthors; Adams and coauthors, 1990; Mooney and Arthur; and Rosenzweig and Parry). Crop-growth models mathematically simulate plant development given data on climate, soils, management practices, growth processes, and (often) atmospheric CO_2.[8]

Typically, crop-growth models are run under current temperature, precipitation, and CO_2 conditions to provide base yields and then again under conditions suggested by various climate change scenarios. Because crop-growth models are site and crop specific, country/region level impacts must be obtained by inference. Additionally, since only a few major crops have been modeled, yield effects are often extrapolated to other crops. In a variation, Kane and coauthors develop a moderate climate change scenario from a review of the climate change-crop response literature.

Regression analysis and analogous regions have also been used to estimate impacts of climate change on crop yields. Arthur and Abizadeh (1988) estimate climate-dependent yield regressions for various crops and locations in Canada's Prairie Region. Mooney and Arthur impose crop yields from North Dakota, South Dakota, and Minnesota on different parts of Manitoba to mimic yields under hotter and drier conditions in central Canada. The analogous regions approach has also been used in several noneconomic studies of climate change and agriculture.

Rosenzweig and Parry (1994) look at how climate change might affect the location of U.S. wheat production by looking at where wheat is grown under current climate conditions; Parry (1990) does the same thing for maize (grain and silage) in the United Kingdom.

Several approaches have been used to incorporate climate change-induced, crop-yield effects into

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[6]We focus here on studies that model economic impacts of climate change on agriculture. A comprehensive review of the literature dealing with global climate change and agriculture is U.S. Congress, Office of Technology Assessment.

[7]Commonly cited GCMs are the GISS model (Goddard Institute for Space Studies) (Hansen and coauthors, 1983), the GFDL model (Geophysical Fluid Dynamics Laboratory) (Manabe and Wetherald, 1987), the UKMO model (United Kingdom Meteorological Office) (Wilson and Mitchell, 1987), the OSU model (Oregon State University) (Schlesinger and Zhao, 1989), and the NCAR model (National Center for Atmospheric Research) (Washington and Meehl, 1984).

[8]Commonly used crop-growth models include CERES (wheat, maize, and rice), EPIC (wheat, maize, and sorghum), GAPS (maize and sorghum), and SOYGRO (soybeans).

economic models. At the farm and nation/region levels, mathematical programming techniques have been popular. For a farm in southern Minnesota, Kaiser and coauthors use discrete, stochastic, sequential programming to model annual production decisions over a 100-year period under gradually changing climate conditions. Production decisions are made in two stages; preharvest operations and harvest operations. In making decisions, farmers know past weather, market conditions, and crop-growth processes but have only probabilistic knowledge of future yields, grain drying costs, field time availability, and crop prices. Crop options are maize, sorghum, and soybeans.

Adams and coauthors (1990) use quadratic programming to analyze impacts of climate change on the U.S. farm sector--including producer welfare, consumer welfare, output mix, and input usage. Their model of U.S. agriculture includes 64 production regions, 10 input supply regions, and 1,683 output mixes for maize, soybeans, rice, cotton, barley, sorghum, rice, alfalfa, and livestock. Inputs considered are land, labor, and water. In a similar work, Adams and coauthors (1988) assess the impacts of climate change on irrigated agriculture in the western United States.

Mooney and Arthur use linear programming to analyze how climate change might affect the net revenue maximizing mix of barley, wheat, canola, oats, sunflower, maize, soybeans, and potatoes in Manitoba. Arthur and Abizadeh do a similar analysis for Canada's entire Prairie Region.

At the global level, two frameworks have been used to model impacts of climate change on agriculture. Kane and coauthors use the Static World Policy Simulation (SWOPSIM) framework to analzye how climate-induced changes in regional crop yields would affect world commodity markets. Their model includes 13 regions and 20 commodities. For each region and each commodity, supply, demand, and net trade equations are specified. The system is first solved assuming no climate change. Climate change-induced impacts on crop yields are then entered into the regional supply equations and the system is solved again for new equilibrium production, consumption, and price levels. Reilly and Hohmann extend the Kane and coauthors work by increasing the number of regions to 33 and considering a more extensive set of crop yield impacts.

Rosenzweig and Parry use the Basic Link System (BLS) to extend analysis of world commodity markets under climate change to a dynamic general equilibrium framework. The BLS contains 34 country/region models that differ in structure but are linked through trade in 10 commodities and financial flows. The system is solved simultaneously for all country/regions in annual increments. The commodity "nonagriculture" makes the BLS a general equilibrium framework. Production of nonagriculture is modeled with a Cobb-Douglas functional form using capital and labor as inputs.

The studies reviewed above present some interesting findings concerning agriculture and climate change. Kaiser and coauthors consider three climate change scenarios. In each, after allowing for adaptation, net farm income is higher relative to the base case. This suggests that in areas with good agricultural resources, farmers will not be economically hurt by climate change.

Most country/region studies also find that agricultural producers, with adaptation, are better off with climate change (Adams and coauthors, 1990, Mooney and Arthur). Consumers and society, however, are usually worse off. Adams and coauthors (1990) show that the economic impacts vary significantly with the scenario considered. For the United States, their estimated impacts range between -$10.33 and +$10.89 billion a year. Adams and coauthors (1990) conclude that the major effects of climate change on U.S. agriculture will be regional shifts in production and (perhaps) a reduced supply role in some world commodity markets. Their results suggest, however, that climate change could greatly increase demands for land and water resources. Hence, some concern for the future of natural ecosystems seems warranted.

Kane and coauthors find that economic impacts of climate change will be small, both nationally and globally. Their moderate climate change scenario assumes substantial yield declines in some regions but world prices, consumption, and production are adjusted by trade. Overall, world food output increases slightly, while world food prices decrease slightly. Rosenzweig and Parry add a major caveat to this finding. They estimate a maximum decline in global cereal production of 5 percent, but note that output declines are concentrated in poor countries. Hence, the main effects of climate change on world agriculture could be falling output in developing countries, rising world commodity prices, and increasing numbers of people at risk from hunger.

Appendix 2: A Simple AGE Model with Heterogeneous Land Resources[9]

The methods described in this paper to delimit region-land class combinations and assign to each such combination a commodity output mix, define a production possibilities curve for the land resources of each modeled region. The method of modeling climate change shows how the shape of these curves would shift in response to specified changes in temperature and precipitation levels. Where a region operates on its production possibilities curve is an economic question. Hence, to analyze the impacts of shifts in regional land class endowments on commodity markets, requires a model that accounts for the shifts as well as the economic interactions between sectors and between regions. To make this point more concrete, consider the following simple Applied General Equilibrium (AGE) model developed with hypothetical data.

The model has two regions (Home and Rest of World (ROW)), three goods (Grains, Other Agriculture (OtherAg), and Nonagriculture (NonAg)), three sectors (1, 2, and 3), and three inputs (Land 1, Land 2, and Capital). Sectors 1 and 2 each produce a mix of Grains and OtherAg. Production in these sectors is input-output separable (that is, the optimal input mix is not affected by a change in the relative price of the two outputs, and changes in relative input prices do not influence the output mix). Each sector has a constant elasticity of substitution (CES) cost function and a constant elasticity of transformation (CET) revenue function. Sector 3 produces only NonAg and its cost function is also CES. Capital is fixed at 500 units in Home and 490 units in ROW. Capital has free mobility across sectors within a region but there is no international factor mobility.

Initially, Home (ROW) is endowed with 20 (5) units of Land 1 and 5 (20) units of Land 2. The two land classes differ with respect to agricultural productivity (say, due to different climates). By assumption, Land 1 favors Grains production while Land 2 is better suited to producing OtherAg. Land 1 is specific to (is only used by) Sector 1, where it is combined with Capital and NonAg inputs to produce a Grains-OtherAg mix that is relatively intense in Grains. At initial prices, the ratio of Grains to OtherAg produced in Sector 1 is 4:1. Land 2 is specific to Sector 2, where it is combined with Capital and NonAg inputs to produce a Grain-OtherAg mix that is relatively intense in OtherAg. The ratio of Grains to OtherAg produced in Sector 2 at initial prices is 1:4. Sector 3 uses Capital and NonAg inputs to produce NonAg.

Each region has a single consumer with a nested CES utility function. At the bottom level of the utility functions, Grains and OtherAg are combined into a composite good "Food" using an elasticity of substitution of 1.0 (the Cobb-Douglas form). At the top level, NonAg is combined with Food using an elasticity of substitution of 0.1. Endowments of Land and Capital are the only sources of consumer income and there is no public sector.

Grains and OtherAg are not differentiated by region of origin. Hence, Home and ROW grain (OtherAg) are perfect substitutes. Neither region exports and imports the same agricultural good. Initially, Home exports grain and ROW exports OtherAg. NonAg is differentiated by region of origin. Each region exports and imports NonAg; initially, Home is the net exporter. We assume nearly identical preferences and production technologies in the two regions. Hence, trade results primarily from differences in regional factor endowments (the Heckscher-Ohlin result).

In two simulations, we exogenously shift regional land class endowments (say due to climate change).[10] In Scenario 1, each country has an increase in the stock of its most abundant land class. For Home (ROW), one unit of land shifts from Land 2 (1) to Land 1 (2). In Scenario 2, both countries experience a one unit shift of land from Land 2 to Land 1.

Simulation results are given in table B.1. At initial prices and resource endowments, Home produces 85 units of Grain and 40 units of OtherAg; ROW produces 40 units of Grain and 85 units of OtherAg. The movement of one unit of land from Land 2 (1) to Land 1 (2) in Home (ROW) represents a shift in Home's (ROW's) agricultural production possibilities curve. Note, though, that there is no change in global factor endowments and thus no shift in world agricultural production possibilities. Also note that the initial equilibrium conditions are specified such that, in each region, the ratio of

[9]Condensed from, "Modeling Climate Change and Agricultural Trade with a CGE Model," presented paper, International Agricultural Trade Research Consortium Meeting, St. Petersburg Beach, Dec. 13-15, 1992. This paper is available from the authors.

[10]In FARM, the GIS determines the changes in land class endowments that result from specified climate-change scenarios.

capital to land in Sectors 1 and 2 is equal to two. Hence, when one unit of land is shifted to Land 1 (Land 2) in Home (ROW), the two units of capital that are released from Sector 2 (Sector 1) become employed in Sector 1 (Sector 2). With no capital moving to Sector 3 in either region, no changes in global factor endowments, and with technology and consumer preferences held constant, there are no changes in relative prices and NonAg production is unaffected.

In Home, grain production increases from 85 to 88 units while production of OtherAg declines from 40 to 37 units. In ROW, grain production decreases from 40 to 37 units and OtherAg production increases from 85 to 88 units. Note that Scenario 1 does not affect income in either country. With income and prices unchanged, consumption is also unchanged. The impact of Scenario 1 on trade, then, is equal to the changes in production. Home exports 3 more units of Grain and imports 3 more units of OtherAg.

Scenario 1 makes the point that important regional impacts related to climate change might not be reflected in world price and production levels. With no changes in prices or global factor endowments, very modest changes in regional land class endowments generated proportionately much larger shifts agricultural production and trade. In each country, 4 percent of the land changed land classes.[11] Relative to the initial equilibrium, however, there was a 3.5 percent increase in Grains (OtherAg) production and a 7.8 percent decrease in OtherAg (Grains) production in Home (ROW). Additionally, trade in Grains and OtherAg increased 15 and 10 percent, respectively.

In Scenario 2, Home and ROW each experience an increase in their endowment of Land 1 and a decrease in their endowment of Land 2. In both countries, this change favors Grain production. This causes a decline in the price of Grains relative to OtherAg and NonAg. In Home, the change in relative prices favors NonAg production. That is, relative to the price of Grain or OtherAg, NonAg becomes less expensive to produce in Home.[12] Since Home increases production of NonAg, its total agricultural production declines. In ROW, NonAg becomes relatively more expensive to produce, so ROW's production of NonAg declines.

Scenario 2 helps illustrate the importance of using a general equilibrium framework when analyzing the potential impacts of climate change on world food markets. While the shifts in land class endowments impact only the Grain and OtherAg sectors directly, much of the economy-wide adjustments occur in the NonAg sectors. The changes in relative prices affect output in all three sectors.

[11]Within regions and for the world as a whole, the GISS GCM climate change results suggest much larger shifts in land class endowments than 4 percent (see table 8).

[12]Home exports Grains, the price of which falls in Scenario 2, and imports OtherAg, the price of which increases. These price changes generate an incipient deficit in Home's balance of trade. The increase in Home's NonAg output results from the requirement that it balance the value of exports and imports. The price of Home NonAg declines relative to ROW NonAg. Additional exports induced by this change in relative prices help balance the trade accounts of both regions.

Table B.1—Summary of simulation results

Item	Initial equilibrium	Scenario one	Scenario two
Land endowments			
Land 1	20	21	21
Land 2	5	4	4
Land 1*	5	4	6
Land 2*	20	21	19
Prices			
Grain**	1.000	1.000	1.000
OtherAg	1.000	1.000	1.041
NonAg	1.000	1.000	1.017
NonAg*	1.000	1.000	1.022
Land 1	1.000	1.000	0.973
Land 2	1.000	1.000	1.097
Land 1*	1.000	1.000	0.955
Land 2*	1.000	1.000	1.077
Quantities			
Grain	85	88	85.60
Grain*	40	37	41.91
OtherAg	40	37	37.90
OtherAg*	85	88	84.52
NonAg	1,000	1,000	1,001.30
NonAg*	980	980	978.80
Grain exports	20	23	19.41
OtherAg exports*	30	33	30.53
NonAg exports	100	100	101.35
NonAg imports	90	90	88.79

* implies ROW, ** implies numeraire good

Table 1—Land class boundaries and principal crops

Land class	Days of growing season	Days with soil temperatures above 5° C	Principal crops and cropping patterns	Sample regions
1	0 to 100	125 or less	Sparse forage for rough grazing	U.S.: northern Alaska World: Greenland
2	0 to 100	More than 125	Millets, pulses, sparse forage for rough grazing	U.S.: Mojave Desert World: Sahara Desert
3	101 to 165	More than 125	Short season grains, forage: one crop per year	U.S.: Paloose, western Nebraska World: Baltic States, southern Sweden
4	166 to 250	More than 125	Maize: some double-cropping possible	U.S.: Corn Belt World: northern European Community
5	251 to 300	More than 125	Cotton, rice: double-cropping common	U.S.: Tennessee World: Zambia, nonpeninsular Thailand
6	301 to 365	More than 125	Rubber, sugarcane: double-cropping common	U.S.: Florida and southeast coast World: Indonesia

Table 2—Land class areas under current climate

Land class	United States	Canada	Europe	Former USSR	Japan and Australasia	Other Asia	Latin America	Africa	Temperate	Tropical	Total	Share
	Million hectares											Percent
1	120	504	164	1,135	4	263	77	3	1,927	343	2,270	17
2	301	79	10	633	506	945	289	1,424	1,530	2,658	4,188	32
3	116	310	89	544	102	271	69	198	1,161	538	1,699	13
4	199	29	181	71	112	202	156	385	592	743	1,335	10
5	69	0	46	0	35	275	266	315	150	856	1,006	8
6	111	0	17	0	70	582	1,161	639	199	2,382	2,581	20
Total	917	922	507	2,384	829	2,539	2,018	2,964	5,558	7,520	13,079	100

Note: Europe excludes areas in the former USSR. "Temperate" includes the United States, Canada, Europe, the former USSR, and Japan and Australasia. "Tropical" includes Other Asia, Latin America, and Africa.

Table 3—Distribution of land uses across the regions' land classes

Land use and land class	United States	Canada	Europe	Former USSR	Japan and Australasia	Other Asia	Latin America	Africa	Temperate	Tropical	Total	Share
	Million hectares											Percent
Arable:												
1.	0	0	1	14	0	1	1	0	14	3	17	1
2	37	15	2	86	3	99	12	30	144	141	285	20
3	23	18	25	104	13	58	4	20	184	81	265	18
4	94	13	89	28	15	63	12	46	238	121	359	25
5	19	0	16	0	5	114	22	32	41	168	210	15
6	17	0	5	0	17	115	99	53	40	267	307	21
Pasture:												
1	13	14	6	136	1	73	30	1	171	105	276	8
2	137	8	4	272	345	293	96	377	766	766	1,532	45
3	23	5	20	74	35	73	24	108	157	205	362	11
4	38	1	35	12	27	48	57	183	113	288	401	12
5	18	0	14	0	10	46	94	92	43	232	275	8
6	12	0	5	0	14	101	285	140	30	526	556	16
Forest:												
1	36	133	68	563	1	20	9	2	801	31	832	21
2	49	28	3	44	32	26	30	17	155	73	228	6
3	51	185	37	331	33	56	28	24	638	108	746	18
4	54	12	37	22	41	52	60	82	167	193	360	9
5	29	0	7	0	10	95	110	161	46	366	413	10
6	75	0	5	0	20	292	661	403	100	1,355	1,455	36
Other:												
1	71	357	89	422	2	168	36	0	940	204	1,145	27
2	78	28	1	231	126	527	151	1,000	465	1,678	2,143	51
3	19	101	7	34	20	84	13	46	182	144	325	8
4	13	3	20	9	28	39	27	75	74	141	215	5
5	3	0	8	0	9	20	39	30	20	89	109	3
6	8	0	2	0	19	74	116	43	29	234	263	6

Note: Europe excludes areas in the former USSR. "Temperate" includes the United States, Canada, Europe, the former USSR, and Japan and Australasia. "Tropical" includes Other Asia, Latin America, and Africa.

Table 4—Crops by land class and region

Cropland use	United States	Canada	Europe	Former USSR	Japan and Australasia	Other Asia	Latin America	Africa	Temperate	Tropical	Total	Share
	Million metric tons											Percent
Wheat and cool-season grains:												
1	0	0	1	11	0	1	1	0	12	2	14	2
2	19	19	3	68	1	65	2	6	111	73	184	21
3	14	28	56	90	9	43	2	3	196	48	245	28
4	44	3	160	26	11	57	8	8	243	74	317	37
5	13	0	16	0	2	59	11	3	31	73	105	12
6	0	0	0	0	0	0	0	0	0	0	0	0
Total	89	50	237	194	23	226	24	21	593	271	864	100
Percent	10	6	27	22	3	26	3	2	69	31	100	NA
Maize, millets, and sorghum:												
1	0	0	0	0	0	0	0	0	0	0	0	0
2	19	0	1	5	0	44	5	21	26	70	96	17
3	1	0	3	0	0	2	0	0	4	3	8	1
4	147	7	29	8	0	32	8	7	191	47	238	42
5	30	0	8	0	0	49	7	0	38	57	95	17
6	19	0	3	0	1	39	40	27	23	106	129	23
Total	216	7	45	13	1	167	60	55	283	282	565	100
Percent	38	1	8	2	0	30	11	10	50	50	100	NA
Paddy rice												
1	0	0	0	0	0	1	0	0	0	1	1	0
2	0	0	0	2	1	118	0	4	3	122	125	24
3	0	0	0	0	0	18	0	1	0	19	19	4
4	1	0	2	0	10	33	2	1	13	35	48	9
5	2	0	0	0	2	110	1	0	4	110	114	22
6	4	0	0	0	1	188	13	7	6	208	214	41
Total	7	0	2	2	14	468	15	12	26	495	521	100
Percent	1	0	0	0	3	90	3	2	5	95	100	NA

—Continued

Table 4—Crops by land class and region—Continued

Cropland use	United States	Canada	Europe	Former USSR	Japan and Australasia	Other Asia	Latin America	Africa	Temperate	Tropical	Total	Share
	Million metric tons											*Percent*
Ubiquitous nongrains:												
1	0	0	1	6	0	1	1	0	7	2	8	0
2	19	2	6	64	0	96	14	72	91	182	273	14
3	10	2	68	110	4	50	4	5	194	59	252	13
4	85	8	287	41	16	78	24	17	437	119	556	29
5	25	0	59	1	15	247	36	40	100	323	423	22
6	30	0	8	0	3	222	86	41	41	349	390	20
Total	168	12	427	223	39	693	164	175	869	1,033	1,902	
Percent	9	1	22	12	2	36	9	9	46	54		
Tropical nongrains:												
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	66	43	22	0	130	131	11
3	0	0	0	0	0	12	5	1	0	18	18	2
4	0	0	0	0	0	17	5	1	0	23	23	2
5	0	0	0	0	0	69	3	0	0	72	72	6
6	26	0	0	0	27	373	477	81	53	930	984	80
Total	26	0	1	0	27	536	532	106	54	1,174	1,228	
Percent	2	0	0	0	2	44	43	9	4	96		

Note: Europe excludes areas in the former USSR. "Temperate" includes the United States, Canada, Europe, the former USSR, and Japan and Australasia. "Tropical" includes Other Asia, Latin America, and Africa.

Table 5—Distribution of livestock across the regions' land classes

Livestock and land class	United States	Canada	Europe	Former USSR	Japan and Australasia	Other Asia	Latin America	Africa	Temperate	Tropical	Total	Share
	100,000 head											*Percent*
Dairy cows:												
1	0	0	1	11	1	2	7	1	13	9	22	1
2	12	3	6	168	5	123	72	90	194	284	478	22
3	10	6	52	185	9	80	16	24	261	120	381	17
4	61	9	372	81	16	62	33	50	539	144	683	31
5	6	0	34	0	8	138	58	32	49	228	276	13
6	8	0	6	0	13	88	183	46	27	318	344	16
Total	96	17	470	445	53	492	369	242	1,081	1,104	2,185	100
Percent	4	1	22	20	2	23	17	11	49	51	100	NA
Nondairy cattle:												
1	3	1	1	23	3	169	67	6	31	241	272	3
2	244	51	10	330	99	642	472	505	734	1,618	2,353	22
3	102	31	82	288	49	355	98	174	553	627	1,180	11
4	310	22	605	125	65	424	225	372	1,127	1,021	2,148	20
5	100	0	61	0	29	917	410	228	190	1,555	1,745	16
6	126	0	12	0	62	893	1,583	363	200	2,838	3,038	28
Total	885	105	771	766	308	3,399	2,854	1,646	2,836	7,900	10,736	100
Percent	8	1	7	7	3	32	27	15	26	74	100	NA
Pigs:												
1	0	1	1	15	0	180	18	0	17	198	215	3
2	45	17	34	274	12	472	137	17	381	626	1,007	12
3	33	36	234	336	17	518	41	12	656	571	1,227	14
4	370	51	1,417	166	76	715	85	46	2,079	847	2,925	34
5	44	0	106	0	32	774	118	31	181	923	1,105	13
6	47	0	21	0	11	1,569	372	56	80	1,997	2,076	24
Total	538	104	1,812	791	149	4,228	771	163	3,394	5,161	8,555	100
Percent	6	1	21	9	2	49	9	2	40	60	100	NA

—Continued

Table 5—Distribution of livestock across the regions' land classes—Continued

Livestock and land class	United States	Canada	Europe	Former USSR	Japan and Australasia	Other Asia	Latin America	Africa	Temperate	Tropical	Total	Share
	100,000 head											Percent
Sheep & goats:												
1	1	0	8	132	41	475	144	10	183	629	812	5
2	65	3	41	976	745	2,943	316	1,682	1,830	4,942	6,771	38
3	17	2	301	455	381	1,175	97	414	1,156	1,686	2,842	16
4	30	3	1,035	84	373	785	146	807	1,525	1,738	3,262	18
5	11	0	185	0	196	679	153	330	391	1,162	1,553	9
6	7	0	51	0	563	735	636	496	621	1,866	2,488	14
Total	114	8	1,620	1,646	2,298	6,792	1,493	3,738	5,686	12,023	17,709	100
Percent	1	0	9	9	13	38	8	21	32	68	100	NA
Other:												
1	0	0	0	8	0	21	8	1	9	29	38	2
2	14	2	1	51	2	366	56	150	69	572	641	29
3	6	1	7	25	1	148	14	17	39	178	217	10
4	20	1	36	11	1	214	22	24	68	260	329	15
5	6	0	2	0	0	441	38	5	9	484	493	22
6	7	0	0	0	1	370	108	14	9	491	500	23
Total	54	4	46	94	4	1,559	246	210	203	2,015	2,217	100
Percent	2	0	2	4	0	70	11	9	9	91	100	NA

Note: Europe excludes areas in the former USSR. "Temperate" includes the United States, Canada, Europe, the former USSR, and Japan and Australasia. "Tropical" includes Other Asia, Latin America, and Africa.

Table 6—Distribution of forests across the regions' land classes

Forest and land class	United States	Canada	Europe	Former USSR	Japan and Australasia	Other Asia	Latin America	Africa	Temperate	Tropical	Total	Share
	Million hectares											*Percent*
Conifer:												
1	50	141	59	511	0	7	0	0	760	7	767	65
2	30	7	0	5	0	2	0	0	42	2	44	4
3	40	125	15	153	2	12	0	0	336	12	348	29
4	10	6	8	0	1	4	0	0	25	5	30	3
5	0	0	1	0	0	1	0	0	1	1	1	0
6	13	0	1	0	0	1	2	0	14	3	18	1
Total	142	279	60	669	3	27	2	0	1,154	29	1,183	100
Percent	12	24	5	57	0	2	0	0	98	2	100	NA
Broadleaf:												
1	0	0	1	3	1	2	6	2	4	10	14	1
2	0	0	0	3	8	18	21	44	11	83	95	5
3	0	0	3	15	10	25	14	25	29	65	93	5
4	10	0	8	3	25	19	45	83	46	148	194	10
5	4	0	1	0	5	52	101	138	11	290	301	16
6	1	0	0	0	12	222	586	326	13	1,134	1,147	62
Total	15	0	18	24	61	339	780	620	118	1,739	1,857	100
Percent	1	0	1	1	3	18	42	33	6	94	100	NA
Mixed:												
1	0	5	4	72	0	13	17	0	82	31	113	11
2	1	8	2	13	24	7	13	6	48	26	74	7
3	11	60	13	163	21	19	14	7	268	41	309	31
4	40	6	30	18	15	28	17	8	110	53	163	16
5	23	0	6	0	5	42	14	11	35	67	102	10
6	60	0	3	0	8	66	47	38	72	151	223	22
Total	136	79	80	266	74	176	115	68	636	359	995	100
Percent	14	8	8	27	7	18	12	7	64	36	100	NA

Note: Europe excludes areas in the former USSR. "Temperate" includes the United States, Canada, Europe, the former USSR, and Japan and Australasia. "Tropical" includes Other Asia, Latin America, and Africa.

Table 7—Distribution of timber harvests across the regions' land classes

Timber type and land class	United States	Canada	Europe	Former USSR	Japan and Australasia	Other Asia	Latin America	Africa	Temperate	Tropical	Total	Share
	Million cubic meters											*Percent*
Softwood:												
1	39	46	91	171	0	10	4	0	347	14	361	27
2	24	3	2	4	4	3	3	0	37	7	44	3
3	58	83	55	121	11	30	6	1	328	36	364	27
4	59	7	94	8	13	34	11	1	181	46	227	17
5	27	0	19	0	4	33	10	3	51	46	96	7
6	122	0	19	0	6	54	46	11	147	111	258	19
Total	330	140	280	303	38	164	80	16	1,091	260	1,351	100
Percent	24	10	21	22	3	12	6	1	81	19	100	NA
Hardwood:												
1	0	1	4	11	0	7	1	0	16	9	24	1
2	0	1	1	3	1	16	3	10	6	29	36	2
3	7	12	23	43	4	46	4	10	89	59	149	8
4	51	2	70	8	11	64	13	47	142	125	267	14
5	33	0	11	0	3	151	32	93	46	277	323	16
6	77	0	6	0	4	582	222	272	88	1,077	1,164	59
Total	168	16	116	64	23	867	276	433	388	1,576	1,964	100
Percent	9	1	6	3	1	44	14	22	20	80	100	NA

Note: Europe excludes areas in the former USSR. "Temperate" includes the United States, Canada, Europe, the former USSR, and Japan and Australasia. "Tropical" includes Other Asia, Latin America, and Africa.

Table 8—Land class areas under a simulated climate with a doubling of atmospheric carbon dioxide levels

Land class	United States	Canada	Europe	Former USSR	Japan and Australasia	Other Asia	Latin America	Africa	Temperate	Tropical	Total	Share
	Million hectares											Percent
1	58	299	134	645	0	187	44	2	1,135	232	1,367	10
2	271	83	8	682	487	851	267	1,481	1,530	2,599	4,129	32
3	169	391	60	715	126	371	85	267	1,462	722	2,184	17
4	169	143	107	336	108	388	300	465	863	1,153	2,016	15
5	94	2	85	3	40	188	352	294	224	834	1,058	8
6	155	4	113	3	69	555	970	456	344	1,980	2,324	18
Total	917	922	507	2,384	829	2,539	2,018	2,964	5,558	7,520	13,079	100
Change:												
1	-62	-205	-31	-490	-4	-76	-33	-2	-792	-111	-903	NA
2	-30	4	-2	49	-20	-95	-21	57	1	-59	-59	NA
3	53	82	-29	171	24	100	16	69	301	184	485	NA
4	-30	114	-74	265	-4	186	144	80	271	410	682	NA
5	25	2	40	3	5	-87	86	-22	74	-23	51	NA
6	43	4	96	3	-1	-28	-192	-183	145	-402	-257	NA
	Percent											
Percent change:												
1	-52	-41	-19	-43	-94	-29	-43	-50	-41	-32	-40	NA
2	-10	5	-22	8	-4	-10	-7	4	0	-2	-1	NA
3	46	26	-32	31	24	37	23	35	26	34	29	NA
4	-15	389	-41	373	-3	92	92	21	46	55	51	NA
5	37	NA	87	558	13	-32	32	-7	49	-3	5	NA
6	39	NA	556	581	-2	-5	-16	-29	73	-17	-10	NA

Note: Europe excludes areas in the former USSR. "Temperate" includes the United States, Canada, Europe, the former USSR, and Japan and Australasia. "Tropical" includes Other Asia, Latin America, and Africa.

U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT #AIB-688

Three Forces Drive World Feed Wheat Trade

February 1994

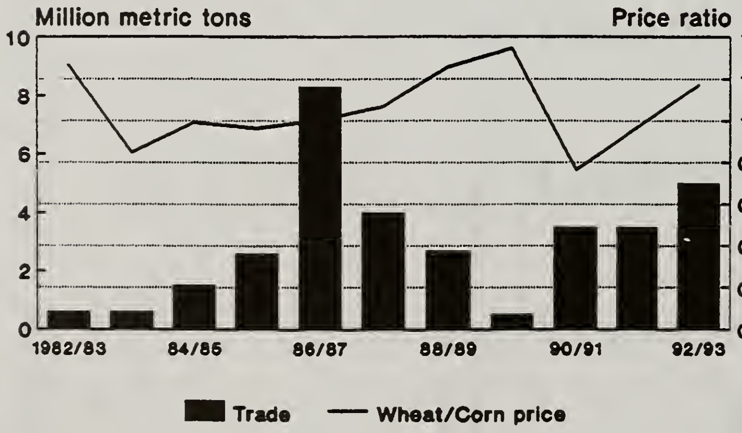
Contact: Sara Schwartz, 202/219-0825

Competitive prices and abundant wheat supplies generally increase trade in wheat for feeding. Certain types of market conditions increase the probability that large volumes of feed wheat will be traded. These market conditions include: damaged wheat in exporting countries that leads to heavy price discounts; abundant total wheat supplies that drive down export prices, often aggravated by fierce and subsidized competition among exporters; and a combination of the first two conditions that lowers relative wheat prices. *World Feed Wheat Trade: A Market Analysis*, a recent report from USDA's Economic Research Service, examines the key factors affecting feed wheat trade and thus develops a framework for evaluating the necessary conditions.

While the annual volume of feed wheat trade fluctuates widely, it has been increasing since the mid-1980's. Although much wheat that is traded and fed is low quality, there is no standard definition of feed wheat; any wheat can be used for feeding. Trade accounts for only a small and irregular portion of world consumption of wheat for feed, but feed wheat trade critically affects the volume of total wheat and coarse grain trade.

The world market for feed wheat is relatively small, with few countries importing wheat for feed, even in years when relative prices are attractive. Policy impediments and other factors, such as the irregular availability of low-priced wheat, restrict import demand. The world market is undergoing some structural change because of reduced demand by the former Soviet Union (FSU) and Eastern Europe, major importers in the past. Because of reforms and economic changes, the livestock sectors in these countries are contracting, and feeding of all grains is declining. In the short term, this will further increase the dominance of South Korea, which now has close to monopsony power in the world market. Other countries could import more feed wheat, but this would require more flexibility in imports or policy changes.

World feed wheat trade and wheat/corn ratio 1/



1/ Feed wheat prices unavailable. Ratio comprised of composite milling wheat price to US Gulf f.o.b. corn price.

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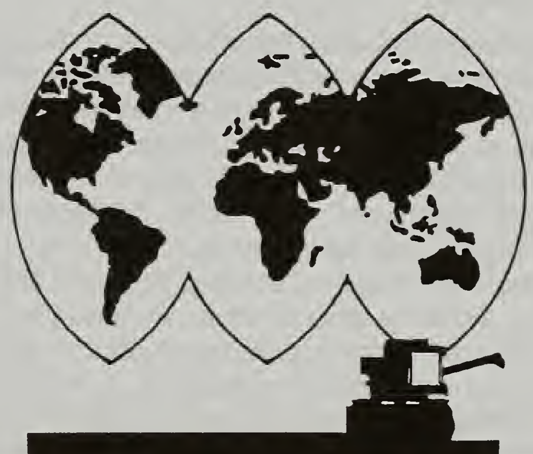

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SUMMARY OF REPORT #TB-1827

Effectiveness of Integrated Pest Control Depends on Local Environments

December 1993

Contact: Margriet F. Caswell or Robbin A. Shoemaker, (202) 219-0434

The success of adopting new farming practices to reduce the use of pesticides depends on the environmental characteristics of the area in which the practices are used. The U.S. Department of Agriculture has proposed that farmers reduce the use of pesticides by adopting integrated pest management strategies, a system in which farmers choose pest management practices appropriate to the specific environment. These practices have been promoted through the USDA Water Quality Initiative in response to public concerns about possible chemical contamination of groundwater from agriculture. Adoption of the practices would be encouraged through a combination of education and cost-sharing programs. Under some environmental conditions, integrated pest management shows promise of reducing pollution of ground and surface water.

Techniques Must Be Chosen for Local Conditions

The effectiveness of an integrated pest management technique depends on local environmental conditions. IPM practices have a range of very different technical and physical or biological relationships. The programs make use of chemical, biological, cultural, mechanical, and genetic techniques. This report, *Adoption of Pest Management Strategies Under Varying Environmental Conditions* from USDA's Economic Research Service, provides a technical analysis of several policy instruments designed to encourage the adoption of chemical-reducing pest management strategies. A model is developed that provides an analysis of systematic differences among possible techniques as these relate to the specific environment and describes the effects of these techniques if they were put into place.

The choice of the best pest management strategy depends on such factors as land quality, climate, degree of infestation, and other local considerations. Pesticide loadings (the amount of chemical available for runoff or leaching) can be determined for a range of environmental characteristics. The resulting water quality will depend on the correlation of the environment with the amount of chemical residuals.

Two Pest Management Strategies Cited

Two types of IPM strategies--biological controls and crop rotation--illustrate the effectiveness of alternative practices in reducing chemical loadings. The profits associated with alternative practices, which will affect voluntary adoption of the practices, are examined. The reasons for choosing the methods are derived, and the sensitivity of the choices to environmental, technological, and economic factors is discussed. An analysis follows of the effects of the methods on farmer profitability, land use, and chemical loadings when the new techniques are in use.

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